PHYSIOLOGICAL AND PSYCHOLOGICAL EFFECTS OF SPACE FLIGHT

VOLUME II
WEIGHTLESSNESS AND SUBGRAVITY

J. F. PRICE

RESEARCH BIBLIOGRAPHY No. 44

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PHYSIOLOGICAL AND PSYCHOLOGICAL EFFECTS OF SPACE FLIGHT: A Bibliography

Volume II

Weightlessness and Subgravity

by

J. F. Price

Research Bibliography No. 44

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FOREWORD

This bibliography, consisting of 385 references (mostly annotated) on weightlessness and sub-gravity studies is the second in a series of volumes pertaining to the physiological and psychological effects of space flight. The majority of references are those published during the period January, 1952, to November, 1962. Author, agency, periodical, subject and ASTIA indices are included.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the help received by the following individuals without which this bibliography would not have been possible:

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Research Bibliography No. 40
THE LUNAR PROBLEM, by L. R. Magnolia and J. R. Trew,
VOL. I - BIBLIOGRAPHY, Oct. 61. AD 268 706, 269 pp., 1030 refs ,
VOL. II - INDEX, Oct 61, AD 268 705, 35 pp ; also reprinted by STL as two volumes in one and assigned Rept. no. 9990-6142-KU-000.

All phases of lunar exploration programs, lunar trajectory and guidance requirements, and basic lunar research are included. Volume II contains author, source, and fields of interest indices.

Research Bibliography No. 41
MASERS AND LASERS: A Bibliography, by J F. Price and A. K. Dunlap,
Rept. no. 9990-6052-KU-R01, (Apr. 62) Rev. Jun. 62, AD 274 843, NASA N62-16763, 161 pp., 4 indices, 1294 refs.

Approximately eight hundred maser references, five hundred optical maser (laser) references, and additional references on irasers, frasers, and rasers are included. Whenever possible the references listed in the bibliography have been reviewed in order to include the maximum amount of retrival data. Author, agency, periodical, and ASTIA indices are included.

Research Bibliography No. 42
INTERPLANETARY MATTER: A Bibliography, by L. R. Magnolia,
Rept. no. 9990-6058-KU-000, June 62, AD 276 064, NASA N62-16764,
591 pp., 5 indices, 1650 refs.

This bibliography consists of 1650 references (mostly annotated) on asteroids, comets, cratering, meteorites, meteors, micrometeorites, noctilucent clouds, nonterrestrial dust, origin of the solar system, tektites, the zodiacal light, and related subjects. The majority of the references are those published between January, 1950, and March, 1962. Author, subject, agency, periodical, and ASTIA indices are also included.

Research Bibliography No. 43
PHYSIOLOGICAL AND PSYCHOLOGICAL EFFECTS OF SPACE FLIGHT: A Bibliography, Volume I, Acceleration, Deceleration, and Impact, by J. F. Price,
Rept. no. 9990-6302-KU-000, Oct 62, 368 pp , 5 indices, 1020 refs

This bibliography on acceleration, deceleration, and impact studies, is the first of a series of volumes pertaining to the physiological and psychological effects of space flight. The majority of the references are those published between January, 1950, and August, 1962. Author, subject, agency, periodical, and ASTIA indices are included.

CONTENTS

1. Adams, C. C.
"Human Factors In Space Flying", chapter 10, pp. 239-277, fig., tbl., 126 refs., in; SPACE FLIGHT, McGraw-Hill, New York, 1958, 373 pp.

A review of work being done in Space Medicine with sections on Radiation, Vision, Respiration, Acceleration, Weightlessness, Heat Problems, Space suits and meteors.

2. Air Force, Wright-Patterson AFB, Ohio
USE OF V-2 ROCKET TO CONVEY PRIMATE TO UPPER ATMOSPHERE, by D. G. Simons, Rept. no. TR 5821, May 49.

3. Air Force, Aeronautical Systems Div., Aerospace Medical Lab., Wright-Patterson AFB, Ohio
EFFECTS OF POSTURE ON CARDIOVASCULAR CHANGES INDUCED BY PROLONGED WATER IMMERSION, Rept. for Mar-May 61, on Biophysics of Flight, by D. E. Graveline, Proj. 7222, Oct 61, AD 270 869, 6 pp., illus., 7 refs.

Previous hypodynamic research using water-immersion techniques was done with the subjects in a semi-reclining position. To evaluate the possible influences of posture and relative immobilization on the cardiovascular deterioration associated with prolonged water immersion, a technique was employed which allowed complete freedom of activity, position, and attitude. Five subjects were evaluated for functional change after 6 hours in this environment. The results indicate that postural factors play an insignificant role in the mechanism of cardiovascular alteration induced by water immersion.

4. Air Force, Aeronautical Systems Div., Aerospace Medical Lab., Wright-Patterson AFB, Ohio
WEIGHTLESSNESS AND PERFORMANCE - A REVIEW OF THE LITERATURE, by J. P. Loftus and L. R. Hammer, Proj. 7184, Task 71585, Rept. no. TR 61-166, Jun 61, 39 pp., 125 refs.

The implications of weightlessness as encountered in space flight are discussed, and the known research dealing with the psychological and physiological effects of zero gravity is critically reviewed. Topics are grouped under the headings of orientation, psychomotor performance, and physiological functions, with a special section on methods of research. The major problem area indicated is the effect of weightlessness on gravity oriented sensory mechanisms, particularly the vestibular apparatus, and consequently on both physiological functions and psychomotor performance. An extensive bibliography is included.

5. Air Force, Aerospace Medical Div., Behavioral Sciences Lab., Wright-Patterson AFB, Ohio
THE EFFECT OF TRANSIENT WEIGHTLESSNESS ON VISUAL ACUITY, by L. D. Pigg and W. N. Kama, Proj. 7184, Rept. No. TR 61-184, Mar 61, AD 261 906, 21 pp., illus., tbls.

Visual acuity was measured on subjects while they were exposed to short periods of weightlessness aboard an aircraft flown through zero-g trajectories involving transition from 1 g to 2-1/2 g to zero g. Monocular and binocular acuity of near and far vision were measured on both Snellen and checkerboard targets. Control measurements were made on the ground and in-flight at 1 g in counter-balanced sequence with the zero-g measurements. Results show that the weightless environment produced for this study has a detrimental effect on visual acuity as measured. The decrement is not considered to have practical significance. (Author)

6. Air Force, Aerospace Medical Div., Behavioral Sciences Lab., Wright-Patterson AFB, Ohio
SELF-MANEUVERING FOR THE ORBITAL WORKER, by J. C. Simons and M. S Gardner, Proj. 7184, Task 71585, Rept. no. TR 60-748, Dec 60, 22 pp.

Current studies on the psychophysiological problems (spatial orientation, rotation rates, tumble recovery, visual capabilities in space) facing workers in the zero-gravity environment of an orbiting space vehicle are summarily reviewed. Four motions appear to be basic requirements for the worker to perform his duties: (1) rotation to proper translation path (flight path); (2) translation between desired positions with rotation to achieve a feet-first landing approach; (3) rotation during arrival to a desired work position; and (4) stabilization in that position until the job is finished. Studies of various self-propulsions and stabilization systems under weightless conditions indicate that gyrostabilization and torque-induced precession of gyros appear the most economical methods of handling the problems of radial stabilization and rotation, while rocket propulsion appears necessary for complete translation. Methods of achieving rotation, translation, and stabilization are evaluated in terms of mobility of the worker and economy of energy and presented in a table.

7. Air Force, Aerospace Technical Intelligence Center, Wright-Patterson AFB, Ohio
DETAILS OF THE LEGENDARY FLIGHT, Trans. no. MCL-1035, 27 Jul 61, AD 261 805, 25 pp., from; Komsomol'skaya Pravda, v. 91 (11031), 16 Apr 61, pp. 1-3.

8. Air Force, Aerospace Technical Intelligence Center, Wright-Patterson AFB, Ohio
FIVE HOURS WITH YURIY GAGARIN, by P. Barshev and V. Peskov, Trans. no. MCL-1151, 27 Jul 61, AD 261 825, 7 pp., from: Komsomol'skaya Pravda, 15 Apr 61, p. 4.

9. Air Force, Aerospace Technical Intelligence Center, Wright-Patterson AFB, Ohio
MAN AND SPACE, by N. Sisakyan, Trans. no. MCL-1149, 27 Jul 61, AD 261 823, 6 pp., trans. of Pravda, v. 85 (15575), 26 Mar 61, p. 5.

10. Air Force, Aerospace Technical Intelligence Center, Wright-Patterson AFB, Ohio
MAN TECHNOLOGY AND SPACE, by G. Pokrovskii, Trans. no. MCL-851, 27 Mar 61, AD 258 837, 14 pp., from; Ekon. Gaz., v. 102 (774), 27 Sep 60, p. 304.

11. Air Force, Air Technical Intelligence Center, Wright-Patterson AFB, Ohio
MAN IN SPACE: MEDICAL-BIOLOGICAL PROBLEMS IN SPACE FLIGHTS, by I. Rakh, O. Gorlov, V. Yakovlev and Ye. Yogov, Rept. no. ATIC-1256169, 7 Oct 59, 35 pp., from; Vses. Obshc. Raspr. Polit. i Nauch. Znanii (USSR), ser. 8, v. 1, no. 20, 1958.

The pamphlet describes in a popular vein problems such as acceleration, weightlessness, radiation, meteoric danger, lowered barometric pressure, hypoxia, sealed cabins, space suits, temperature, water and food, re-entry and demands on future astronauts. Ample data are included on Sputnik 2 and the dog Layka.

12. Air Force, Inst. of Technology, Wright-Patterson AFB, Ohio
OPTIMIZATION OF MANNED ORBITAL SATELLITE VEHICLE DESIGN WITH RESPECT TO ARTIFICIAL GRAVITY, by B. J. Loret, Rept. no. ASD TR 61-688, Dec 61, AD 277 446, 46 pp., illus., 41 refs.

A design envelope is established as the result of a human factors analysis of the artificial gravity environment peculiar to rotating space vehicles. The envelope is prescribed by: an upper limit on vehicle angular velocity of 0.4 radian/second to minimize the occurrence of "canal sickness"; a basic upper limit on artificial gravity of 1 g; and a basic lower limit on artificial gravity of 0.2 g as the lowest value of g at which man can walk unaided. Both g-limits are modified to compensate for Coriolis forces which cause variation in g-level for tangential walking inside the rotating vehicle. An upper limit on vehicle radius of 180 feet is established on the basis of engineering practicality. The optimum vehicle configuration is established as a Modified Axially Expanded Dumbbell, characterized by a single, cylindrical, living-working compartment oriented parallel to the spin axis, counterbalanced by other

Continued

vehicle components. The configuration is illustrated in the conceptual Pseudo-Geogravitational Vehicle, which has a radius of 180 feet and an operational angular velocity of 0.4 radian/second to produce 0.9 g in the living-working compartment.

13. Air Force Missile Development Center, Holloman AFB, N. Mex. AIRBORNE GALVANIC SKIN RESPONSE STUDIES: A PRELIMINARY REPORT, by G. J. D. Schock, Rept. no. TN 59-14, Jun 59, AD 215 465, 10 pp., fig., 3 refs.

Preliminary data show the galvanic skin response (GSR) of human subjects to be unaffected by weightlessness per se. GSR data indicate changes are due to emotional factors such as anxiety.

14. Air Force Missile Development Center, Holloman AFB, N. Mex. APPARENT MOTION OF A FIXED LUMINOUS TARGET DURING SUBGRAVITY TRAJECTORIES, by G. J. D. Schock, Rept. no. TN 58-3, Feb 58, AD 135 009, 12 pp.

During flying of a ballistic trajectory, human subjects experienced apparent motion of a fixed luminous target. This motion appeared to be downward during increased acceleration and upward during deceleration. During weightlessness no target motion was apparent, indicating that no oculogravic illusion may result during transition from normal gravity conditions into weightlessness.

15. Air Force Missile Development Center, Holloman AFB, N. Mex. BEHAVIOR OF THE CHIMPANZEE ON A COMPLEX MULTIPLE SCHEDULE, by R. E. Belleville, F. H. Rohles, Jr., and M. E. Grunzke, Proj. 6893, Rept no. AFMDC-TR-61-27, Aug 61, 22 pp., 4 figs., 2 tbls., 13 refs.

This report describes chimpanzee behavior on a four component, three lever multiple schedule. The component schedules included the Sidman avoidance procedure with a concurrent discriminated avoidance feature on a second lever; fixed ratio performance for food, differential reinforcement of low rate for water requiring a dual response chain, and a symbol discrimination task for continuous food reinforcement using three levers. The advantages of employing this type of schedule for evaluating the effects of exposure to space flight conditions are discussed.

16. Air Force Missile Development Center, Holloman AFB, N. Mex. COMPLEX AVOIDANCE BEHAVIOR IN THE CHIMPANZEE AND ITS APPLICABILITY TO THE STUDY OF SPACE ENVIRONMENTS, by R. E. Belleville, F. R. Rohles, Jr., M. E. Grunzke and F. C. Clark, Proj. 6893, Task 68930-68931, Rept. no. AFMDC-TR-60-27, Sep 60, 20 pp., 4 figs., 10 refs.

Continued

This report describes the concurrent development of two types of avoidance behavior in the chimpanzee in which a discrete avoidance task was superimposed on a schedule requiring continuous avoidance behavior. The rationale for using these tasks for measuring the behavioral effects of space flight is presented.

17. Air Force Missile Development Center, Holloman AFB, N. Mex FEEDING DEVICES FOR USE WITH PRIMATES IN SPACE FLIGHT, by M. E. Grunzke, Proj. 6893, Rept. no. AFMDC-TR-61-35, Dec 61, 18 pp., 8 figs., 3 refs.

This report describes two devices that can be employed for dispensing food and water to primates that are undergoing space flight. Also provided are the functional diagrams for basic conditioning and for more complex reinforcement schedules.

18. Air Force Missile Development Center, Holloman AFB, N Mex FLIGHT EXPERIMENTS ABOUT HUMAN REACTIONS TO ACCELERATIONS WHICH ARE FOLLOWED OR PRECEDED BY THE WEIGHTLESS STATE, by H. J. von Beckh, Rept. no. TN 58-15, Dec 58, AD 154 108, 42 pp., 16 figs., 22 refs.

Flight experiments which simulated Pre-weightlessness and Post-weightlessness acceleration were conducted in jet aircraft. It was shown that alternations of acceleration and the weightless state decrease the acceleration tolerance of the subject and the efficiency of the physiological recovery mechanisms. The implications for planning of manned space flight are; (1) thrust values and re-entry profiles must take the lower acceleration-tolerance into consideration; and (2) adequate G-protection must be designed for the pilot, to prevent dangerous effects of unavoidable high accelerations. (Author)

19. Air Force Missile Development Center, Holloman AFB, N. Mex. A LABORATORY MODEL FOR A 14-DAY ORBITAL FLIGHT WITH A CHIMPANZEE, by F. H. Rohles, Jr., H. H. Reynolds, M. E. Grunzke and O. N. Farrer, Proj. 6893, Rept. no. AFMDC-TR-61-33, Oct 61, 55 pp., 13 figs., 14 tbls., 4 refs.

A young male chimpanzee was restrained on a plastic couch and isolated from the usual laboratory distractions for 14 days. Assuming a 90 minute orbit, the subject performed a complex psychomotor task for approximately nine hours each day and received all of his food and water as rewards for his performance. Skin temperature, pulse, and respiration were monitored through the test and urine and feces were collected outside the isolation cubicle and measured. The subject lost no weight for the test period and recovery was rapid.

20. Air Force Missile Development Center, Holloman AFB, N. Mex. PERCEPTION OF THE HORIZONTAL AND VERTICAL IN SIMULATED SUBGRAVITY CONDITIONS, by G. J. D. Schock, Rept. no. TN-59-13, Jun 59, AD 215 464, 15 pp., 6 tbls., 3 refs.; Also in Armed Forces Med. J., v. 11, no 7, Jul 60, pp. 786-793.

Quantitative experiments show that in simulated subgravity conditions with decreased proprioceptive input, perception of the horizontal and vertical is greatly impaired. During actual space flight artificial gravity forces may be needed to insure adequate human orientation during weightlessness.

21. Air Force Missile Development Center, Holloman AFB, N. Mex. SENSORY REACTIONS RELATED TO WEIGHTLESSNESS AND THEIR IMPLICATIONS TO SPACE FLIGHT, by G. J. D. Schock, Proj. 7851, Rept. no. TR 58-6, Apr 58, AD 135 012, 14 pp., 10 refs.

The implications of a sensory-starved environment have been reviewed and compared to conditions that will prevail in actual space flight. Recommendations for training for future space flight are presented.

22. Air Force Missile Development Center, Holloman AFB, N. Mex. A STUDY OF ANIMAL REFLEXES DURING EXPOSURE TO SUBGRAVITY AND WEIGHTLESSNESS, by G. J. D. Schock, Rept. no. TN 59-12, Jun 59, AD 215 463, 17 pp., 3 tbls., 6 refs.

Normal cats exposed to weightlessness display loss of labyrinthine reflexes, disorientation and confusion, with and without visual cues. Cats in which the vestibular cortical area of the brain had been removed bi-laterally seem to be less disoriented and confused than normal animals, but also display loss of labyrinthine reflexes. Bi-labyrinthectomized cats, however, are relatively unaffected by exposure to weightlessness and display no symptoms of serious disorientation and confusion.

23. Air Force Missile Development Center, Holloman AFB, N. Mex A TECHNIQUE FOR INSTRUMENTING SUBGRAVITY FLIGHTS, by G. J. D. Schock and D. G. Simons, Proj 7851, Rept. no. 58-4, Feb 58, AD 135 008, 20 pp. 7 figs., 4 refs.

Instrumentation was designed to achieve the maximum duration of weightlessness using F-94C aircraft. Observations on the behavior of different fluids under subgravity and weightless conditions indicate a study under extended periods of true weightlessness is worthwhile for planning and designing future space vehicles.

24. Air Force Missile Development Center, 6571st Aeromedical Research Lab., Holloman AFB, N. Mex.
A DETAILED ACCOUNT OF CHIMPANZEE PERFORMANCE DURING THE BALLISTIC AND ORBITAL PROJECT MERCURY FLIGHTS, by F. H. Rohles, Jr., M. E. Grunzke and H. H. Reynolds, Proj. 6893, Task 689301-689302, Rept. no. ARL-TDR-62-15, Jul 62, 40 pp., 11 figs., 2 tbls., 10 refs.

Two space flights with chimpanzees were made as part of the Project Mercury program. In the first flight the subject was placed through a ballistic trajectory and during the flight had to perform a continuous and discrete avoidance task. During a second flight in which the capsule orbited the earth twice, a chimpanzee had to perform a complex multiple operant task.

25. Air Force Missile Development Center, Office of Information Services, Historical Div., Holloman AFB, N. Mex.
HISTORY OF RESEARCH IN SUBGRAVITY AND ZERO-G AT THE AIR FORCE MISSILE DEVELOPMENT CENTER, HOLLOMAN AIR FORCE BASE, NEW MEXICO, 1948-1958, by D. Bushnell, May 58, 46 pp., 37 refs.

26 Air Force School of Aviation Medicine, Brooks AFB, Tex.
AN EXPLORATORY STUDY OF CHANGES IN PROFICIENCY IN A HYPODYNAMIC ENVIRONMENT, by B. Hartman, R. E. McKenzie and D. E. Graveline, Rept. no. 60-72, Jul 60, 13 pp.

Simulated weightlessness for a prolonged period (50 hr. to 7 days) was produced by the body immersion technique. Changes in psychomotor efficiency on a relatively simple task were assessed during immersion and after return to the normal environment of one g. Systematic increases in response time during the 7-day period in the hypodynamic environment were obtained. Gross disruptions in psychomotor behavior upon return to the normal one-g state were observed. When compared to a control run, these were increased response times, in three different kinds of tasks. These results suggest that the functional capabilities of a man exposed to a prolonged period of weightlessness will be seriously impaired during the re-entry phase of space flight. (Authors' summary, modified)

27. Air Force School of Aviation Medicine, Brooks AFB, Tex.
AN EXPLORATORY STUDY OF STEEP CHARACTERISTICS IN A HYPODYNAMIC ENVIRONMENT, by R. E. McKenzie, B. Hartman and D. E. Graveline, Rept. no. 60-58, Oct 60.

28. Air Force School of Aviation Medicine, Brooks AFB, Tex.
HYPODYNAMIC UROLITHIASIS: A POTENTIAL HAZARD DURING PROLONGED WEIGHTLESSNESS IN SPACE TRAVEL, by A. T. K. Crockett, C. C. Beehler and J. E. Roberts, Review no. 2-62, Dec 61, 6 pp., fig., 10 refs.

Continued

The relative immobilization of astronauts may be a major cause of serious metabolic shifts in calcium metabolism during prolonged space travel. Several etiologic factors in urinary lithiasis which will be present during spaceflight are emphasized.

29. Air Force School of Aviation Medicine, Brooks AFB, Tex. THE PHYSIOLOGIC EFFECTS OF HYPODYNAMICS INDUCED BY WATER IMMERSION, by D. E. Graveline and B. Balke, Rept. no. 60-88, Sep 60, AD 247 163, 11 pp., 12 figs., 6 tbls., 6 refs.

Body immersion in water was used to produce an experimental situation in which the normal weight sensation was altered and in which slow movements were effortless. The hypodynamic effects of such immersion on orthostatic tolerance, on cardiorespiratory adaptability to physical stress, and on other biologic and psychophysiologic parameters were studied on one human subject in experiments of two- and seven-days duration, respectively. Pronounced functional deterioration resulted from the hypodynamic situation in both experiments; cardiovascular reflexes were severely disturbed and muscular tone was diminished. The extensive biochemical studies on blood and urine showed marked deviations from the normal. Psychomotor effectiveness, tested on a complex systems task, was impaired noticeably. The need for sleep appeared to be markedly reduced during the periods of water immersion. This area of research is vital to the man-in-space program. Weightless or near-weightless conditions in space flight are expected to produce a similar hypodynamic effect on the organism as was caused by water immersion. Such loss of functional reserves may severely interfere with the astronaut's capability to adjust adequately to returning gravitational forces

30. Air Force School of Aviation Medicine, Brooks AFB, Tex. PHYSIOLOGIC RESPONSE TO WEIGHTLESSNESS INITIATION OF MICTURITION, by J. E. Ward, W. R. Hawkins and H. D. Stallings, Rept no. 59-35, Aug 59, 5 pp.

To study the effect of the null-gravity state on elimination of liquid body rates, 26 subjects were exposed to a total of 37 separate jet aircraft flights during which zero-gravity parabolic flight maneuvers were performed. The capability of the subjects to initiate micturition during weightlessness following a period of hydration was studied.

31. Air Force School of Aviation Medicine, Brooks AFB, Tex SOME OBSERVATIONS ON THE BEHAVIOR OF A VISUAL TARGET AND A VISUAL AFTER-IMAGE DURING PARABOLIC FLIGHT MANEUVERS, by J. A. Roman, B. H. Warren, J I. Niven, and A. Graybiel, Rept. no. SAM-TDR-62-66, Jun 62, 8 pp., 3 figs., 4 tbls., 6 refs. (Joint report with U. S. Naval School of Aviation Medicine)

Continued

The apparent displacement of a real target and a visual after-image were observed in the F-100F aircraft during periods of weightlessness averaging 45 seconds. The experimental results are used as a background from which to reconcile apparent discrepancies between the findings of different investigators.

32. Air Force School of Aviation Medicine, Randolph AFB, Tex. CORRELATION OF STATE AND PHYSICAL ENDURANCE, by B. Balke, Proj. no. 21-32-004, Rept. no.1, Apr 52.

33. Air Force School of Aviation Medicine, Randolph AFB, Tex. EPITOME OF SPACE MEDICINE, 1958.

Document contains ten research reports of the School of Aviation Medicine and 31 articles from scientific journals on Space Medicine. Topics discussed include the weightless state, acceleration, radiation effects, high altitude and sealed cabin studies.

34. Air Force School of Aviation Medicine, Randolph AFB, Tex. EXPERIMENTS DURING WEIGHTLESSNESS: A STUDY OF THE OCULO-ACRAVIC ILLUSION, by S. J. Gerathewohl and H. D. Stallings, Jr., Rept. no. 58-105, Jul 58, Also in; J. Aviation Med., v. 29, no. 7, Jul 58, pp. 504-516, AD 203 801, 21 pp., 5 figs., tbl., 16 refs.

To investigate visual illusions during flight, an F-94C type aircraft was flown through various manoeuvres. They included turns, push-overs, pull-ups, and aileron rolls producing accelerations of different directions and magnitude, as well as short periods of weightlessness. The observer induced a strong visual after-image and described its apparent motion and displacement associated with the manoeuvre. Increase of radial acceleration was found to be associated with an apparent downward movement, and subgravity or weightlessness, with an apparent upward movement of the visual after-image. This latter phenomenon was called the 'oculo-agravic illusion'.

35. Air Force School of Aviation Medicine, Randolph AFB, Tex. "The Peculiar State of Weightlessness", by S. G. Gerathewohl in; MEDICAL PROBLEMS OF SPACE FLIGHT, Ed. by A. J. Kendricks, Special rept. Aug 55.

36. Air Force School of Aviation Medicine, Randolph AFB, Tex. PHYSIOLOGIC RESPONSE TO SUBGRAVITY. I. MECHANICS OF NOURISHMENT AND DEGLUTITION OF SOLIDS AND LIQUIDS, by J. E. Ward, W. R. Hawkins and H. Stallings, Jr., Rept. no. 59-2, Jan 59, 4 pp., 2 figs., 4 refs., Also in; J. Aviation Med., v. 30, no. 3, Mar 59, pp. 151-154.

Continued

To study the mechanics of nourishment during weightlessness, 165 sub-gravity parabolas were flown in an F-94C aircraft. Twenty-five subjects attempted to drink from an open container, a container with a pierced lid and plastic straw, and a plastic squeeze bottle. Observations were also made regarding deglutition of solids, including swallowing of both well and poorly masticated pieces of food.

37. Air Force School of Aviation Medicine, Randolph AFB, Tex. PRIMATES IN SPACE: REPORT NO 2, BIOASTRONAUTICS ADVANCES IN RESEARCH, by J. E. Pickering, W. L. Brown, H. D. Stallings, R. E. Benson, R. W. Bellner, H. L. Bitter, R. M. Carr and A. A. McDowell, Mar 59.

38. Air Force School of Aviation Medicine, Randolph AFB, Tex. PRODUCING THE WEIGHTLESS STATE IN JET AIRCRAFT, by S. J. Gerathewohl, O. L. Ritter and H. D. Stallings, Rept. no 57-143, Aug 57, AD 149 703, 11 pp., 6 figs., tbl., 11 refs., Also in; Astronaut. Acta, v. 4, no. 1, 1959, pp. 15-24, and USAF School of Aviation Med., Randolph AFB, Tex., EPITOME OF SPACE MEDICINE, item 10, 1958.

Some simple arithmetic functions were used for computing duration, height, and angle of climb of flight parabolas for producing the weightless state in jet aircraft. The results, based upon certain flying characteristics of the T-33, F-94, and F-104, are in good agreement with the data obtained for the first two types of aircraft mentioned during actual zero-gravity maneuvers. Certain flying safety hazards were noticed in the T-33 but remedied through appropriate measures. The F-94C Starfire proved to be superior to the T-33 with regard to safety and duration of weightlessness obtained. If the F-104 were made available for aeromedical research, weightlessness could be produced for more than 1 minute.

39. Air Force School of Aviation Medicine, Randolph AFB, Tex. REPORTS ON SPACE MEDICINE - 1958, Feb 59.

Contents include:

Hauty, G. T., "Human Performance in the Space Travel Environment."

Ward, J. E., S. J. Gerathewohl and G. R. Steinkamp, "Supersonic and Hypersonic Human Flight."

Ward, J. E. and G. R. Steinkamp, "Human Engineering of the Sealed Space Cabin."

Hauty, G. T. and R. B. Payne, "Fatigue, Confinement, and Proficiency Decreement."

Hawkins, W. R., "The Feasibility of Recycling Human Urine for Utilization in a Closed Ecological System."

Hawkins, W. R. and G. T. Hauty, "Space Cabin Requirements as Seen by Subjects in the Space Cabin Simulator."

Gerathewohl, S. J., "Weightlessness - The Problem and the Air Force Research Program."

40. Air Force School of Aviation Medicine, Randolph AFB, Tex. REQUIREMENTS FOR PRESENT-DAY EXPERIMENTAL ZERO GRAVITY PARABOLAS, by J. E. Ward, Rept. no. 57-121, Jul 57, AD 143 896, 6 pp., 4 figs., 5 refs., Also in; J. Aviation Med., v. 29, no. 6, 1958, pp. 428-432.

In simplified form, graphs are presented which allow rapid determination, without calculation, of parabolic entry velocity, angle of climb at entry, and vertical altitude traveled during the trajectory as a function of the total duration of zero gravity and minimum speed attained during the parabola (determined by stalling speed) by the experimental aircraft. (Author)

41. Air Force School of Aviation Medicine, Randolph AFB, Tex. STUDY ON SUBGRAVITY STATES, by F. Haber, Proj. no. 21-34-003, Rept. no. 1, Apr 52, 9 pp., 7 figs., 4 refs., Also in; Air Force School of Aviation Medicine, Randolph AFB, Tex., EPITONE OF SPACE MEDICINE, paper no. 4.

The equations of motion of a body under subgravity conditions are discussed. The applications to an elevator and airplane are explained and the obtainable duration of subgravity and zerogravity calculated. The short period of time available in elevators does not warrant the use of this means. An airplane with an initial speed of 450 m.p.h. makes it possible to maintain zerogravity for 35 seconds.

42. Air Force Systems Command, Aeronautical Systems Div., Aerospace Medical Lab., Wright-Patterson AFB, Ohio AERONAUTICAL SYSTEMS DIVISION STUDIES IN WEIGHTLESSNESS: 1959-1960, Ed. by L. R. Hammer, Proj. 7184, Task 71585, Rept. no. TR 60-715, Dec 61, AD 273 098, 93 pp., 43 figs., 29 refs.

Facilities and techniques used at Aeronautical Systems Division to study the effects of weightlessness are described; completed experiments and those started before January 1961 are discussed. Topics are grouped under two main headings: aerospace medical studies and aeromechanics studies. Specific problem areas and methods of experimentation are emphasized. Findings are briefly stated.

43. Air Force Systems Command, Aeronautical Systems Div., Behavioral Sciences Lab., Wright-Patterson AFB, Ohio EFFECTS OF SIMULATED WEIGHTLESSNESS UPON POSITIONING RESPONSES, by W. N. Kama, Rept. no. ASD TR 61-555, Dec 61, AD 277 288, 12 pp., illus., tbls., 4 refs.

The speed and accuracy of positioning movements as functions of distance, direction, and mass were investigated under simulated weightless conditions. Subjects seated on a

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frictionless device made blind positioning movements by sliding each of two frictionless masses (1000 or 7000 grams) various distances (10, 20, and 40 cm) either left-to-right or near-to-far. Both speed and accuracy decrease with distance; left-to-right movements take longer, but are more accurate than near-to-far movements. Speed decreases with increased mass. With minor exceptions, the effects are similar to those noted when fixed subjects position weightless objects. The responses of fixed subjects were slower, but more accurate, and were not affected by the variable of mass.

44. Air Force Systems Command, Aeronautical Systems Div., Biomedical Lab., Wright-Patterson AFB, Ohio
MAINTENANCE OF CARDIOVASCULAR ADAPTABILITY DURING PROLONGED WEIGHTLESSNESS, by D. E. Graveline, Proj. 7222, Task 72201, Rept. no. TR 61-707, Dec 61, 8 pp.

During prolonged zero gravity because of the absence of hydrostatic pressure influences, special techniques will be necessary to maintain cardiovascular adaptability and provide the orbiting astronaut with optimum tolerance for reentry stresses. A multiple tourniquet approach to intermittently obstruct venous return from the periphery has been devised, simulating the hydrostatic pressure effects of standing and thereby "triggering" compensatory cardiovascular reflexes. Following 6-hour periods of water immersion with tourniquet protection, the orthostatic tolerance of 5 subjects was determinded and compared with that obtained following previous 6-hour immersion tests with no protection. In all subjects the tourniquet technique maintained normal or better than normal cardiovascular adaptability as measured by tilt-table testing.

45. Air Force, Wright Air Development Center, Wright-Patterson AFB, Ohio
MAGNETIC SHOES FOR HUMAN ORIENTATION IN SPACE, by J. F. Nicholson and D. W. Naas, Rept. no. WADC-TN 59-352, Feb 60.

46. Air Force, Wright Air Development Center, Wright-Patterson AFB, Ohio
ZERO GRAVITY RESEARCH AT WRIGHT AIR DEVELOPMENT CENTER (A FILM), by E. Brown, Black and White - 16 mm - Silent - Approx. 22 min. Unclassified - No date of issue or identifying number.

Sequence of shots taken aloft during "Keplerian Trajectories", aboard a C131B Aircraft; illustrates various problems associated with zero "g" states.

47. Air Force, Wright Air Development Center, Aero Medical Lab., Wright-Patterson AFB, Ohio
BIBLIOGRAPHY OF RESEARCH REPORTS AND PUBLICATIONS ISSUED BY THE BIOACOUSTIC BRANCH (1947-1957), by A. Boes, 1957, 22 pp.

48. Air Force, Wright Air Development Center, Aero Medical Lab., Wright-Patterson AFB, Ohio
BIBLIOGRAPHY OF RESEARCH REPORTS ISSUED BY THE BIOPHYSICS BRANCH, by M. Siegfried, Jan 57, AD 126 361, 14 pp.

49 Air Force, Wright Air Development Center, Aero Medical Lab., Wright-Patterson AFB, Ohio
MAN'S ABILITY TO APPLY CERTAIN TORQUES WHILE WEIGHTLESS, by E. Dzendolet and J. F. Rievley, Proj. 7184, Task 71586, Rept. no. TR 59-94, Apr 59, AD 220 363, 28 pp., 9 figs., 7 tbls., 8 refs.

The torque that a maintenance man can exert within a space vehicle while weightless, and hence tractionless, is analyzed. Anthropological literature was reviewed to determine the torques a man can apply under normal conditions. Using elementary physical principles the consequences of applying these torques while tractionless were calculated. Certain of the predictions were verified experimentally. It is tentatively concluded that standard anthropometric data can legitimately be extrapolated to the weightless condition.

Suggestions are advanced regarding (a) the optimum body position for a simple tightening task without using a handhold, (b) the use and location of handholds, (c) maximum torque limitations, (d) the use of impulses, and (e) the design of hand tools.

50. Air Force, Wright Air Development Center, Aerospace Medical Lab., Wright-Patterson AFB, Ohio
PRELIMINARY FLIGHT TEST REPORT, PROJECT SKYHOOK. INFLIGHT STUDY OF STABILIZATION UNIT FOR ORBITAL WORKERS, by J. C Simons, 29 Jun 59.

51. Air Force, Wright Air Development Center, Aerospace Medical Lab., Wright-Patterson AFB, Ohio
RESEARCH ON HUMAN PERFORMANCE DURING ZERO GRAVITY, by E. L. Brown, Task 7158S (C-131 B Aircraft), AF-WP-B, Jun 59.

52. Air Force, Wright Air Development Center, Aerospace Medical Lab., Wright-Patterson AFB, Ohio
A SELECTED BIBLIOGRAPHY CONCERNING PHYSIOLOGICAL FACTORS IN AERO-MEDICAL RESEARCH AND DEVELOPMENT, by J. C. Robinette, Apr 57, AD 126 401, 42 pp.

53. Air Force, Wright Air Development Center, Aerospace Medical Lab., Wright-Patterson AFB, Ohio
WALKING UNDER ZERO-GRAVITY CONDITIONS, by J. C. Simons, Proj. 71585, Rept. no. TN 59-327, Oct 59, 8 pp., 4 figs., 3 refs.

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This is the first report on experiments with permanent magnetic sandals which enable a man to walk with an approximately normal gait under weightless conditions. All four subjects reported an immediate spatial orientation of "down" being where their feet were, as soon as their body rotation stopped. A basic index was formulated to define magnetic requirements in terms of the inductive forces required to hold a subject stationary. A vector analysis of the 1-g walking gait is made, and elements of a zero-gait for further study using variable power electromagnetic shoes are proposed.

54. Air Force, Wright Air Development Div., Aerospace Medical Div., Behavioral Sciences Lab., Wright-Patterson AFB, Ohio
DISCRIMINATION OF DIFFERENCES IN MASS OF WEIGHTLESS OBJECTS, by D. W. Rees and N. K. Copeland, Proj. 7184, Task 71586, Rept. no. TR 60-601, Dec 60, AD 252 161, 20 pp., 10 figs., 8 tbls., 4 refs., 2 appens.

Absence of gravity results in the loss of many familiar kinesthetic cues of weight and friction necessary to man for object discrimination and manipulation. Man's ability to discriminate small differences in mass as opposed to small differences in weight was studied. Four weight series were used, each consisting of a standard (1000, 3000, 5000, or 7000 grams) and nine comparison stimuli. Judgments for mass differences were made with the same weights supported by compressed air on an air-bearing table. Thus, the frictionless aspect of a weightless environment was simulated.

Results show that the mean difference limen, mean standard deviation. amd Weber ratio ($\Delta S/S$) for each standard are much larger for mass than for weight. Thus, to be detected under weightless condition, mass increments must be at least twice as large as the weight increments required for discrimination in a normal weight-lifting situation.

55. Air Force, Wright Air Development Div., Aerospace Medical Div., Behavioral Sciences Lab., Wright-Patterson AFB, Ohio
SPEED AND ACCURACY OF POSITIONING WEIGHTLESS OBJECTS AS A FUNCTION OF MASS, DISTANCE, AND DIRECTION, by William N. Kama, Proj. 7184, Rept. no. TR 61-182, Mar 61, AD 260 131, 19 pp., 6 figs., 12 tbls., 4 refs.

Human performance in positioning weightless objects was investigated experimentally using an air-bearing frictionless table. The subjects moved each four masses (1000, 3000, 5000, and 7000 gram) various distances 10, 20, and 40 cm) in each of two directions over this frictionless table in response to paired light stimuli. The responses were accomplished in complete darkness after the lights were extinguished. Results were analyzed in terms of constant and absolute errors of

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positioning, and response time. From the investigation, we concluded that: (1) mass has little effect on the accuracy of positioning. There is some evidence, however, that response time increases with increase in mass. (2) Distance is a significant variable affecting the direction of error, accuracy, and speed of positioning responses. Response time increase, and accuracy decreases with distance. (3) Direction of movement is a significant variable affecting constant error, absolute error, and speed of positioning responses. Subjects tend to undershoot the mark in near-to-far movements.

56. Air Force, Wright Air Development Div., Aerospace Medical Lab., Wright-Patterson AFB, Ohio
BIBLIOGRAPHY ON AEROMEDICAL RESEARCH WITH ABSTRACTS, by J. C. Robinette, Dec 59, AD 247 101, 104 pp., 315 refs.

This bibliography compiles abstracts of technical documentary reports issued by the Aerospace Medical Laboratory, Wright Air Development Center, from 1957-1959.

57. Air Force, Wright Air Development Div., Aerospace Medical Lab., Wright-Patterson AFB, Ohio
MANUAL APPLICATION OF IMPULSES WHILE TRACTIONLESS, by E. Dzendolet, Proj. 7184, Task 71586, Rept. no. TR 60-129, Feb 60, 12 pp., 9 figs., 3 tbls., 3 refs.

The percentage of naive subjects who, while tractionless in a horizontal plane and anchored by one handhold, push in or pull out a plunger in one motion against various frictional forces and travel distances, decreases directly as the force and distance required. With large-force impulses, the impulse is linear and the situation can be described by the impulse-mementum theorem: $\int_0^t F dt = mv_1 - mv_0$. The shape of the impulse is saw-toothed, and its area approximated by taking three-fourths of the area of a rectangle whose base is the duration, and height, the force of the impulse. For this experiment, the maximum duration of an effective impulse for a required force of 40 pounds is 0.5 seconds for a push-in, and 0.3 seconds for a pull-out impulse. A subject, without a handhold, can seat the plunger with a push, and, in spite of the reaction to the impulse, remain attached to the equipment without unseating it. The technique is to allow the reaction to move the subject over as long a distance as possible and, since the total impulse is constant, thus reduce the force. The reduction in force allows the equipment to remain seated since the force is now less than the frictional force needed for seating.

58. Alexander, G.
FLIGHT PROVES MAN CAN FUNCTION IN SPACE, Aviation Week, v. 70, no. 20, 15 May 61, pp. 31-32

Continued

A description is given of the pilot functions performed and the stresses and loads (weightlessness, peak gravity and re-entry loads) to which pilot and capsule were subjected during the 15 minute Mercury-Redstone flight on May 5, 1961.

59. Anderton, D. A.
WILL PRONE FLIGHT LICK HIGH G-LOADS?, Aviation Week, v. 57, no. 26, 29 Dec 52, pp. 21-22, 24-25

The prone position of the pilot in high-speed airplanes has certain advantages (higher g-tolerance of the pilot, reduction of drag due to decrease of frontal area, improved instrument visibility) and drawbacks (narrowing of field of vision, decrease of visual acuity, aggravation of claustophobic tendencies, discomfort encountered in this abnormal position). A rylon bed designed in 1948 by the Aero Medical Laboratory was tested for 8 to 12 hours without apparent signs of discomfort. Three-dimensional hand control (i.e. operation of all the control surfaces by hand motions only) likewise gave good test results. Restriction of vision (up to 35°) was one of the major complaints raised by the test pilots. -- The paper concludes with a brief discussion of flight tests at accelerations of less than 1g, as would be encountered in space flight. The prone pilot was instrumented for recording of heart rate and electrocardiogram. He was asked to shake his head and to nod during the runs at zero g. There were no ill effects following these movements, but after the subgravity flight there was frequent vertigo. Coordination was not impaired, although there was a tendency to overreach.

60. Armstrong, C. R.
SPACE PHYSIOLOGY, J. Brit. Interplanet. Soc., v. 12, 1953, pp. 172-175

The sensory-motor system of a man living in a gravity-free state is subjected to abnormal handicaps. The muscle and skin pressure senses are gravireceptors and would be useless in a gravity-free state. However, the Vater-Pacini corpuscles being deep pressure receptors in the hands, feet, and joints, would probably continue to function and partially compensate for the loss of the other two receptors. The vestibular apparatus, which controls posture and is stimulated by gravity and by rotary movements, might also fail under zero, or near zero, gravity. Respiration and circulation are felt to present lesser problems. Under zero-gravity conditions, oxygen consumption would be low -- approximately 500 litres per day per person. By utilizing the upper physiological limit of increased oxygen pressure, which is 415 mm Hg, this problem can be minimized.

61. Army Ballistic Missile Agency, Redstone Arsenal, Ala.
SPACE FLIGHT SIMULATOR, by C. L. Barker, Jr., Rept. no. DSP-TR-1-59, 16 Mar 59, 34 pp.

Continued

Objectives of this report are two fold: to examine the problem of rocket flight simulation and possible users of a simulation facility; and to describe a system which is capable of producing repeatable acceleration time histories of any desired booster flight including weightlessness and re-entry. Propulsion calculations for the sled are discussed, and the El Capitan in Yosemite Natl. Park is described as a possible site for this apparatus. A table of characteristics of flight trajectories to produce weightlessness of maximum duration for 8 vehicles is included.

62. Army, Research and Development Command, Bioastronautics Research Unit, Redstone Arsenal, Ala.
OBSERVATIONS ON HEART RATE AND CARDIODYNAMICS DURING WEIGHTLESSNESS, by G. E. Burch and S. J. Gerathewohl, Rept. no. CSCRD-16-5, 13 Nov 59, 14 pp., 5 figs., 3 tbls., 18 refs., Also in; Aerospace Med., v 31, no. 8, Aug 60, pp. 661-669.

A review is presented of various experiments conducted in the United States, Russia, and Italy on the cardiodynamic effects of acceleration and weightlessness. Tachycardia and changes in the EKG within normal ranges were generally noted A tendency to prolonged and fluctuating tachycardia in the early stage of weightlessness and decreased cardiac activity in later stages was observed The entire series of experiments demonstrate that the stresses imposed by acceleration and the episodes of weightlessness encountered in aircraft and biologic missile flights are well within the range of tolerance of the human and animal organism.

63. Armed Services Technical Information Agency, Arlington, Va.
BIO-ASTRONAUTICS - AN ASTIA REPORT BIBLIOGRAPHY,
Feb 59, AD 211 775, 157 pp

This bibliography covers the literature from 1952-1958.

64. Armed Services Technical Information Agency, Arlington, Va.
BIO-ASTRONAUTICS: AN ASTIA REPORT BIBLIOGRAPHY, Feb 60, AD 233 000, 43 pp., (Suppl. to AD 211 775).

Previous bibliographies have covered the literature on bio-astronautics through 1958. This supplemental bibliography brings the subject matter up to date through 1959 insofar as report literature represented by ASTIA holdings, is concerned.

65. Armed Services Technical Information Agency, Arlington, Va.
BIO-ASTRONAUTICS: AN ASTIA REPORT BIBLIOGRAPHY (U), Feb 59, AD 306 007, 9 pp., 48 refs. (Secret Report)

This bibliography covers the subject matter from 1952 through 1958 insofar as report literature, represented by ASTIA holdings is concerned. (Unclassified abstract)

66. Armed Services Technical Information Agency, Arlington, Va.
BIO-ASTRONAUTICS: AN ASTIA REPORT BIBLIOGRAPHY, Feb 60,
AD 315 200, 11 pp., (Suppl. to AD 306 007). (Secret Report)

Previous bibliographies have covered the literature on bio-astronautics through 1958. This supplemental bibliography brings the subject matter up to date through 1959 insofar as report literature, represented by ASTIA holdings, is concerned. (Unclassified Abstract)

67. Augerson, W. S.
"Physiological Responses of the Astronaut in the MR-3 Flight," by W. S. Augerson and C. P. Laughlin, pp. 45-51, in : RESULTS OF THE FIRST U. S. MANNED SUBORBITAL SPACE FLIGHT, National Aeronautics and Space Administration, 1961,
Washington, D. C., 116 pp.

Astronaut Shepard (on his suborbital flight on May 5, 1961) demonstrated physiological responses to 5 minute weightless flight (interrupted by 23 seconds of retrofire) were uneventful. Acceleration-weightlessness transition period produced physiological responses within the limits of intact function. The relative change in pulse rate in going from weightlessness to reentry acceleration was comparable to that in going from 1 g to reentry acceleration on the centrifuge. Special senses, that is vision, semicircular canal function, and hearing, appeared intact throughout the flight. (Author)

B

68. Balakhovskii, I. S.
BIOLOGICAL PROBLEMS OF INTERPLANETARY FLIGHTS, by I. S. Balakhovskii and V. B. Malkin, Piroda, Aug 56, (in Russian), Also in; Behind the Sputniks, ed. by F. J. Krieger, Public Affairs Press, Washington, D. C., 1958.

69. Ballinger, E. R.
HUMAN EXPERIMENTS IN SUBGRAVITY AND PROLONGED ACCELERATION, J. Aviation Med., v. 23, no 4, Aug 52,
pp. 319-321, 372, 2 tbls.

The physiological problems of weightlessness and acceleration are presented. Describes experiments run on the human centrifuge at the Aero Medical Laboratory to determine the optimum acceleration one could safely undergo in attaining an escape velocity.

70. Barker, C. L., Jr.
SPACE FLIGHT ACCELERATION SIMULATOR, Planet. Space Sci., v. 7, Jul 61, pp. 335,344.

Continued

Discussion of a proposal for a space flight acceleration simulator, a ground-based training and research facility, which produces the acceleration-time history of rocket flight and the gravitational fields of the Moon and planets. The track captured capsule carries several trainers or hundreds of pounds of equipment through programed "flights" which duplicate the conditions of boost, zero-g, and re-entry, or any combination thereof. The track consists of a horizontal circular track of 1,000-ft. diameter connected to a vertical track with a total height of about one mile.

71. Bauer, L. H.
SPACE MEDICINE, West Vir Med. J., v. 48, no. 11 Nov 52, pp. 326-327.

A review of space medicine and the problems that man faces in space flight.

72 Benedikt, E. T., Ed.
WEIGHTLESSNESS - PHYSICAL PHENOMENA AND BIOLOGICAL EFFECTS, Plenum Press, New York, 1961, 170 pp

Contents include:
Levine, R. B.,"Zero Gravity Simulation,"pp. 135-153, 8 figs., 3 tbls., 34 refs.
Simons, J. C.,"Current WADD Weightless Research," pp. 154-155, tbl.
Brown, E. L., "Human Performance and Behavior During Zero Gravity,"pp. 156-170, 4 figs.

73. Benson, O. O., Jr.
PHYSICS AND MEDICINE OF THE ATMOSPHERE AND SPACE, Ed. by O. O. Benson, Jr. and H. Strughold, New York, Wiley and Sons, 1960, 645 pp.

Contents include:
Strughold, H., and O. L. Ritter, "The Gravitational Environment in Space," pp. 134-142, tbl., 4 refs.
Gerathewohl, S. J., and J. E. Ward, "Psychophysiologic and Medical Studies of Weightlessness," pp. 422-434, 6 tbls., 37 refs.
Lovelace, W. R., II and A. S. Crossfield, "Biomedical Aspects of Orbital Flight," pp. 447-463, 5 figs., tbl., 18 refs.

74. Bergeret, P.
LIFE IN THE WEIGHTLESS STATE (LA VIE DANS IN MILIEU SANS PESANTEUR), A. Tomes, v. 7, 1952, pp. 219-224

75. Beritov, I. S.
THE MECHANISM OF SPATIAL ORIENTATION IN MAN (O MEKHANIZME PROSTRANCTVENNOI ORIENTANCII CHAIOVEKA), Zhur. Vysshei Nervnoi Deyatel' nosti, v. 9, 1959, pp. 3-13, (in Russian)

76. Biget, P. L.
SEVERAL PHYSIOLOGICAL ASPECTS OF "WEIGHTLESSNESS" (QUELQUES ASPECTS PHYSIOLOGIQUES DU VOL "SANS PESANTEUR"), by P. L. Biget and H. Boiteau, Fusees et recherche aeronautique, v. 2, 1957, pp. 161-165.

77. Bowring, J. I. R.
A HYPOTHETICAL MISSION TO SPACE IN A THREE-MAN SEALED CABIN, by J. I. R. Bowring and B. P. Ebert, Planet. Space Sci., v. 7, Jul 61, pp. 309-323.

Discussion of the problems involved in a 30-day orbital mission including the accelerations during launch, weightless flight, cabin layout, high-acceleration crew seats, restraint systems, feeding devices, and human elimination devices.

78. Brown, J. L.
ORIENTATION TO THE VERTICAL DURING WATER IMMERSION, Aerospace Med., v. 32, no. 3, Mar 61, pp. 209-217, 15 refs.

Investigation conducted on human subjects in the Navy Underwater Escape Training Tank to determine the extent of possible disorientation in a liquid environment when visual, tactual, kinaesthetic, and buoyancy cues are eliminated to a large extent. It is shown that with a moderate amount of disorientating motion, the subjects tend to lose their orientation to the vertical when immersed at a depth of 18 to 25 ft.

79. Butz, J. S., Jr.
ALL IN A WEIGHTLESS DAY'S WORK, Air Force, v. 44, no. 4, Apr 61, pp. 112-113, 6 figs.

A variety of experimental hardware to aid human performance in subgravity is being designed and evaluated in the Air Force's expanding research into problems of weightlessness. Zero-gravity research in a modified C-131 aircraft at Wright Air Development Division, Wright-Patterson AFB, Ohio, has resulted in the construction and testing of more than five separate stability and propulsion systems for men floating freely in space.

80. Brown, E. L.
HUMAN AND SYSTEM PERFORMANCE DURING ZERO G, Paper presented at SAE-AFOSR, Astronautic Symposium, 12-14 Oct 60, Los Angeles, Calif., Preprint no. 2301, 5 pp.

General discussion of the following problems during zero g: human performance on motor and mental tasks; locomotion inside and outside large space vehicles; human perceptive orientation; behavior of liquids; fluid transfer problems; and heat transfer problems. The study is largely the outcome of research using a C-131 transport aircraft flying in a Keplerian trajectory, during which about 15 sec. of zero g can be produced.

81. Brown, E. L.
ZERO GRAVITY TESTS SHOW MAN CAN ADJUST TO SPACE, Aviation Week, v. 69, no. 25, 22 Dec 58, pp. 52-53, 55

Experiments conducted during the past six months both in the laboratory and in actual flight, in which short periods of zero gravity were achieved, reveal that there is no serious decrement in man's performance under these conditions. According to Capt. Edward L. Brown, chief of the Crew Stations Research Section of the Aero Medical Laboratory's Engineering Psychology Branch at Wright Air Development Center in Dayton, Ohio, the experiments indicated that special provisions such as wider spacing of switches and levers, or springs or other restraints to prevent the arm from overshooting when reaching for objects, need not be considered in future space cabins. Without exception, the subjects were able to adjust to zero gravity conditions within seconds. It may be that longer periods of zero gravity and further tests may upset the conclusions reached to date, but as of now, weightlessness does not appear to create as serious a problem for crews as biomedical scientists had predicted.

82. Brown, E. L.
MAN'S ANTICS DURING ZERO GRAVITY, SAE J., v. 69, Feb. 61, pp 52-54.

Description of sensations experienced during brief periods of zero g produced in a C-131B transport aircraft. The necessity of magnetic shoes, and of experiences with their use, are mentioned.

83. Brown, E. L
RESEARCH ON HUMAN PERFORMANCE DURING ZERO GRAVITY, Paper presented at the 1959 Meeting of the Aero Medical Assoc., 27-29 Apr 59, Los Angeles, Calif., Abstracted in: Aerospace Med., v. 30, Mar 59, p. 177.

This laboratory is conducting research on several aspects of human performance during zero gravity periods. The zero gravity condition is produced by flying a C 131B aircraft through a Keplerian trajectory. Periods of apparent weightlessness lasting from 12 to 15 seconds can be achieved. Several experiments on simple motor tasks are being conducted. One experiment is concerned with the speed and accuracy of humans making vertical, rotary switch, push button switch, toggle switch and horizontal motions. Motion pictures have been taken of human subjects during unrestrained free-floating in the cabin of the aircraft. The motion pictures demonstrate that nearly all subjects tend to use underwater-type swimming motions to assist in the control and locomotion of their bodies during zero gravity periods. These motion pictures will be shown at the presentation of this paper. The pilots on this

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experiment (including the author) report no greater difficulty in flying the airplane during zero gravity than during normal gravity. The subjects who have experienced free-floating in the cabin during the zero gravity periods report that the feeling of complete weightlessness, with no restraints on the body, is very exhilarating. In as much as the zero gravity experiments are continuing, it is expected that at the time this paper is presented the results of several controlled experiments on human performance during zero gravity will be reportable.

C

84. Caidin, M.
AVIATION AND SPACE MEDICINE: MAN CONQUERS THE VERTICAL FRONTIER, by M. Caidin and G. Caidin, E. P. Dutton & Co., Inc., New York, 1962, 215 pp.

This is a popular treatise on aviation and space medicine illustrated with many photographs. Topics discussed include the upper atmosphere, historical aspects of aviation medicine, high altitude flight, oxygen supply during flight, decompression chamber flight, pressurization and pressure suit, explosive decompression, gravity, vertigo, zero gravity, and escape and survival.

85. California Inst. of Technology, Jet Propulsion Lab., Pasadena
SPACE TRAVEL, by B. Anderson, Literature search no. 66, 18 Apr 58, 19 pp.

A compilation of unclassified references associated with the problems of space travel with special emphasis on the physiological aspects.

86. Campbell, P. A.
THE PRESENT STATUS OF THE PROBLEM OF WEIGHTLESSNESS, by P. A. Campbell and S. J. Gerathewohl, Texas State J. Med., v. 55, no. 4, Apr 59, pp. 267-274.

Weightlessness is discussed from the point of orientation, control, space sickness, cardiodynamics, and nutrition and elimination.

87. Canada, Defence Research Board, Ottawa
A SELECTED BIBLIOGRAPHY OF THE OPEN LITERATURE ON AVIATION MEDICINE, 1945-1955, by C. D. Gowdey and J. W. Pearce, Jul 55.

88. Celent, C.
HUMAN FACTORS: NEWEST ENGINEERING DISCIPLINE, Electronic Ind., v. 19, no. 2, Feb 60, pp. 85-100, 16 figs., 3 tbls., 33 refs.

Rapid technologic advances have generated problems concerning man-machine compatibility that call for an exhaustive knowledge of human behavior. These problems are especially

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critical in preparing for space travel, in that the man and the machine must be assigned the function each performs best. The space traveler must be protected against high or complex acceleration forces and weightlessness, and the effects of extremes of pressure, temperature, humidity, radiation, noise and vibration. Descriptions are given of various programs from industry, government, non-profit organizations, and private consulting firms which are attempting to solve these problems. Included are studies on the effect of motion and vibration on the ability of the pilot to control his craft; the development of telemetric devices for monitoring physiologic responses during space travel, and for lunar suit communications systems; the development of a satellite simulator to facilitate the design of living and working conditions in future extended-trip space vehicles; and the development of analog computers to simulate control situations in manned space vehicle re-entry.

89. Chernov, V. N.
RESEARCH ON THE FLIGHT OF A LIVING CREATURE IN AN ARTIFICAL EARTH SATELLITE, by V. N. Chernov and V. 1. Yakovlev, ARS J., v. 29, no. 10, pt. 1, Oct 59, pp. 736-742, 10 figs.

A detailed description of Soviet research leading up to the flight of Sputnik II is given along with an analysis of the actual flight.

90. Clamann, H. G.
MEDICINE AND SPACE FLIGHT: MAN IN CAPSULE(MEDIZIN UND RAUMFAHRT: DER MENSCH IN DER KAPSEL), Flugkorper (Wiesbaden), v. 2, no. 1, Jan 60, pp. 16-18. (in German)

In a lecture delivered at Dusseldorf, Germany, the author reviewed current and projected areas of investigation in the medical problems of space flight. The subjects discussed included acceleration tolerance, weightlessness, the use of pressure suits, hazards of Van Allen belt radiations, the food requirements and techniques for space flight feeding, methods of re-cycling water and of CO_2 -O_2 exchange, isolation, and tolerance to high dry-heat temperatures.

91. Clark, C. C.
"GRAVITY PROBLEMS IN MANNED SPACE STATIONS", by C. C. Clark and J. D. Hardy, pp. 104-113, 2 tbls., 71 refs., in; Proceedings of the MANNED SPACE STATIONS SYMPOSIUM, 20-22 Apr 60, Los Angeles, Calif., Publ. by IAS, New York, 1960, 322 pp., Also as; Naval Air Development Center, Aviation Medical Acceleration Lab., Johnsville, Pa., Rept. no. MA-6033, 29 Mar 61, AD 255 592, 30 pp.

Unpowered flight above an atmosphere will produce weightlessness throughout a non-rotating space vehicle or along the axis of rotation of a rotating vehicle and, if man is to live

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in space stations, the relative merits and problems of living in a gravitational or in a weightless environment must be resolved. Four points concerning this problem are emphasized: (a) Restraint systems, both for man and for moveable objects, will have to be developed for use in the weightless (zero G) state; (b) In a rotating space station, velocities of linear or angular motions of the head may have to be kept of low magnitude by using restraints and possibly eye prism devices, mirror walls, etc., to reduce the need for head motions, to avoid disorienting illusions and nausea; (c) Normal growth of the embryo and the young and normal repair of adult tissues, such as bone and muscle, which are affected in cellular patterns by force distributions, may require artificial gravity; (d) It may be necessary to develop exercises and other procedures to use prior to changes of acceleration level to restore or develop tolerance to the new level in spite of acclimatization to the old level.

92. Clark, R. T.
BASIC RESEARCH PROBLEMS IN SPACE MEDICINE: A REVIEW, by R. T. Clark. H. G. Clamann, B. Balke, P. C. Tang, J. D. Fulton, A. Graybiel and J. Vogel, Aerospace Med., v. 31, no. 7, Jul 60, pp. 553-577, tbl., 14 refs.

Report includes studies of the subgravity state during parabolic flight, bio-packs for satellites, disorientation in pilots, closed ecological systems, survival of terrestrial organisms under extreme environmental conditions, and physiological aspects of training and selection for manned extraterrestrial flights.

93. Clemedson, C. J.
SOME BIOPHYSICAL AND MEDICAL PROBLEMS INVOLVED IN MANNED SPACE FLIGHT: A REVIEW, Astronautik (Stockholm), v. 1, no. 1, 1958, pp. 9-36.

The following medical and biological problems, which have to be solved before the first manned space flight will be possible, are reviewed: the effects of gravitational stress; the effects of loss of life-sustaining properties of the terrestrial atmosphere; the problems of food and water supply and of waste disposal during long trips; and effects of the physical stresses of confinement in a narrow cabin under abnormal and adverse physical conditions. The accelerations necessary to reach orbital or escape velocity can be well tolerated by a trained crew properly positioned with respect to the direction of the accelerative forces. The reduced gravity or zero gravity experienced when a satellite or a space vehicle is coasting freely in space is supposed to cause no serious disturbances of the normal physiological functions of the body, but orientation and co-ordination may be difficult during the weightless state before adaptation to the new situation has

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taken place. In the case of long-lasting trips, the storage problem of oxygen and air-purification chemicals as well as of food and water may become critical. Photosynthetic air purification and food synthesis from algal material may be the solution in the future. Exposure to the heavy components of primary cosmic radiation and hits by meteorites may consitute a risk, the magnitude of which is, however, not yet exactly known.

94. Cockett, A. T. K.
ASTRONAUTIC UROLITHIASIS: A HAZARD DURING PROLONGED WEIGHTLESSNESS, by A. T. K. Cockett, C. C. Beehler and J. E. Roberts, Paper read by title at the 1962 Meeting of the Aerospace Medical Assoc., 9-12 Apr 62, Atlantic City, N. J.. Abstracted in: Aerospace Med., v. 33, no. 3, Mar 62, p. 359

A good physical exercise regime will help prevent muscular atrophy during prolonged weightlessness, but the preservation of the skeletal system is another matter. Weightlessness will remove the stress of gravity which normally provides stimulus for osteoblastic activity with calcium deposition in the bony matrix. Acute osteoporosis (e.g. in polio patients) not infrequently produces urinary stones in young patients, because of immobilization and calcium reabsorption form long bones Increased urinary sedimentation during prolonged flight may also contribute to calculus formation. A review of such etiologic factors in urolithiasis and prophylactic measures will be presented.

95. Coe, L. A.
SOME NOTES ON THE REACTIONS OF AIRCRAFT PILOTS TO ZERO GRAVITY, J. Brit. Interplanet, Soc., v. 13, no. 4, Jul 54, p. 244.

Twenty subjects, all qualified pilots, were subjected to near-zero gravity for periods up to 20 seconds by maneuvering a Meteor Mark 7 jet trainer. The following reactions were observed: an immediate feeling of insecurity resulting in a reflex action which caused the subject to clutch at something, usually the seat or the sides of the cockpit; this was followed by a sense of relief and relaxation; simple mechanical actions could be performed, depending greatly on the experience and trust of the subject in the pilot of the aircraft; simple mental arithmetic could be done, with great variation and no obvious pattern; loose floating articles tended to distract the subject; most subjects allowed their arms to float up in front of them unless they were required to do something; no subject felt distress or nausea, most of them enjoyed the experience; dust normally present in the aircraft's atmosphere was soon felt as a considerable nuisance.

96. Combs, N. K.
THOUGHTS ON INTERFERENCE WITH GASTRIC ACTIVITY DURING PROLONGED WEIGHTLESSNESS, Paper presented at the 1962 Meeting of the Aerospace Medical Assoc., 9-12 Apr 62, Atlantic City, N. J., Abstracted in; Aerospace Med., v. 33, no. 3, Mar 62, p. 332.

During prolonged weightlessness, it is believed that gastric action on food could be seriously impaired. A review of physiology texts reveals a disagreement on the role of gravity in stomach processing of food. The weight of food and liquids, it is felt, plays an important role in their passage from the fundus to the pylorus as peristalsis per se is not considered to take place in the upper stomach. In addition, it is difficult to see how the orderly exposure of food to gastric juices could take place if the food were without weight. Inasmuch as prolonged weightlessness cannot be simulated, we can only speculate on some of its effects. Gastric difficulties could pose a serious threat to man's well-being and performance. Until more information is obtained from early space ventures, providing personnel with parasympathomimetic or anticholinergic agents might be indicated.

97. Corazzi, U.
COULD WE LIVE IN SPACE? (POSSIAMO VIVERE NELLO SPAZIO?), Oltre il cielo (Rome), v. 5, no. 90, 1-15 Oct 61, pp. 271-274, (in Italian).

A biographical sketch is presented of Colonel Professor Rodolfo Margaria, director of the Institute of Physiology of the University of Milano. Included is a review of his various studies on high altitude physiology, aviation medicine, space flight physiology, the problem of mammalian resistance to acceleration, protection from accelerative forces, the effects of zero gravity on the otolithic apparatus, respiration and position sense, and the effects of interplanetary voyages on the central nervous system and mental condition.

98. Corkindale, K. G.
PSYCHOLOGICAL PROBLEMS OF SPACE FLIGHT, New Scientist (London), v. 10, no. 236, 23 May 61, pp. 457-459.

The effects of the following psychological stresses on performance and behavior of the astronaut are summarized: high g forces, weightlessness, isolation, restraint, and sensory deprivation.

99. Cornell Aeronautical Laboratory, Inc., Buffalo, N. Y.
THE ABILITY OF SUBMERGED SUBJECTS TO SENSE THE GRAVITATIONAL VERTICAL, by W. S. Diefenbach, Internal research no. 993-004, CAL no. OM-1355-v-1, Jan 61, 39 pp. 26 figs., 2 tbls., 21 refs., appen.

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The ability of human subjects to perceive the vertical when submerged in a buoying fluid and subjected to varying amounts of body tilt was studied in a series of pilot experiments. Experimental equipment employed attempted to minimize positional cues other than those arising from the vestibular apparatus and visceral sources. Gross errors in perception of the vertical were made by all subjects. These errors were repeatable within subjects, and had a high linear correlation with the amount of body tilt. In addition, evidence was found that precision in positioning an unseen control may vary with body tilt. Possible simulation of weightlessness and implications for design of space controls are briefly discussed and further research studies are suggested.

100. Cornell Aeronautical Laboratory, Inc., Buffalo, N. Y.
THE BEHAVIORAL ASPECTS OF WEIGHTLESSNESS, PART I., by B R Bugelski, Contr. AF 29(600)1334, Rept. no. 0-1186-V-1, Nov 57, 41 pp., 5 figs., 33 refs.

The present report is concerned with an evaluation of the literature pertaining to the capacities of organisms to adjust to space conditions, especially the factor of weightlessness, and its bearing upon behavior. Because of gaps in our knowledge revealed by this evaluation, an experimental program is proposed which would add substantially to the known data. Prior investigations and experience have indicated that various species and classes of animals (turtles, rats, monkeys, and man) can survive brief periods of weightlessness as these are approximated in current aircraft and rockets. Human pilots in aircraft have described varying degrees of effectiveness over periods of up to about 20 seconds of weightlessness. Animals have survived brief rocket journeys, but beyond the survival of anesthetized monkeys and some apparently successful "holding on" behavior in rats, we have no data relating to capacities for successful reactions to signals or displays. The experimental proposals describe a program which should establish the fact that monkeys and rats can cope with such signal situations while under weightless conditions.

101. CORNELL PROBES WEIGHTLESSNESS, Aviation Week, v. 68, no. 2, 13 Jan 58, pp. 26-28, fig.

An outline of work being done at Cornell Aeronautical Laboratory, Inc. for Air Research and Development Command. Investigation of the efficiency of man's intellectual functions as opposed to physiological reactions, during weightless space travel in rockets, satellites or other space vehicles.

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102. David, H. M.
WEIGHTLESSNESS LOWERS PERFORMANCE, Missiles & Rkts.,v. 8, no. 21, 22 May 61, p. 36.

Physiological and psychological studies conducted under conditions of weightlessness have brought to light situations which may pose a serious problem to space-flight.

103 David, H. M.
WEIGHTLESSNESS STILL WORRIES SOVIETS, Missiles & Rkts., v. 11, no. 18, 29 Oct 62, p. 27, 2 figs.

Russians voice concern over effects of prolonged flight on blood production and tissue regeneration.

104. DESIGN FOR ZERO-G DINING, Machine Design, v. 32, no. 26, 22 Dec 60, p. 12.

A space kitchen has been designed for feeding one astronaut at a time in a weightless state.

105. DuBridge, L. A.
ADVENTURES IN SPACE, Calif. Inst. Technol. Quart., v. 2, Spring 61, pp. 2-8.

E

106. Educational Research Corporation, Cambridge, Mass.
A BIBLIOGRAPHY ON HUMAN FACTORS RELATED TO MANNED SPACE VEHICLES, Contr. N 61339 294, ERC proj. 496, Oct 59, 48 pp , 130 refs.

This bibliography on human factors related to manned space vehicles is intended to supplement other listings in the same area by adding to rather than by displacing them. A list of such sources is presented alphabetically by author and with annotations that are intended to give the reader some idea whether the citation refers to something he might be interested in. A subject index is included.

107. ELEVATORS TO HELP DETERMINE EFFECTS OF REDUCED GRAVITY ON SUPERSONIC PILOTS, Tech. Data Digest, v. 9, 1950, pp. 11-12.

Discussion, in nontechnical terms, of the problems involved in space travel, with particular attention to problems of weightlessness, orbital phenomena, travel time to planets and stars, and surface conditions on the planets. The importance of space exploration for scientific studies is discussed.

108. Ellingson, H. V.
"Aviation Medicine," pp. 221-246, in; CYCLOPEDIA OF MEDICINE, SURGERY AND SPECIALTIES: REVIEW SERVICE, Ed. by G. M. Pierson and E. L. Bortz, Philadelphia, F. A Davis Company, 1960, 88 refs.

The scope and implications of aviation and space medicine are summarily discussed. Consideration is given to the general and specific stresses which may be encountered, to medical and psychiatric problems, air travel and transportation of patients, pilot and astronaut selection, protective equipment and clothing, and to flying safety and accidents involving nuclear weapons.

109. Errebo-Knudsen, E. O.
SPACEFLIGHT MEDICINE: BIOLOGICAL PROBLEMS OF TRAVELING OUTSIDE THE EARTH'S ATMOSPHERE (RUMFARTSMEDICIN. DE BIOLOGISKE PROBLEMER RED OPHOLD UDEN FOR JORDENS ATMOSFAERE). Naturens Verden (Copenhagen), pp. 1-8, 30-32, Jan 60. (in Danish).

This paper summarizes the results of Russian and American studies in spaceflight, as presented in papers at the 2nd World and 4th European Congress of Aviation Medicine in Rome, Oct 59. Biological, neurological, and physiological problems are considered; some results of experiments with animals are reported. Some details from Project Mercury are given, and the potential dangers of flight in space are reviewed. The possibility of human life on other planets in our solar system is discounted.

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110. FEW PHYSIOLOGICAL CHANGES NOTED IN MONKEY'S WEIGHTLESS FLIGHT Aviation Week, v. 69, no. 25, 22 Dec 58, p. 23.

The longest weightless period achieved thus far with a primate (13.3 min.) produced no significant physiological changes in a 1-pound squirrel monkey fired 300 miles into space in an Army Jupiter intermediate range ballistic missile nose cone as part of a joint Navy-Army medical experiment. Enclosed in a small metal cylinder placed inside a larger capsule, "Gordo" was placed supine with his knees drawn over his chest and equipped with gear to measure his heart action, blood pressure respiration, pulse rate, and voice response. Special instruments were installed to measure the temperature and pressure inside the smaller cylinder. A physiological telemetric system developed by Captain Norman L. Barr, chief of the Navy's aviation and space medicine program, and a telemetric system developed by the Army provided information.

111. Flecker, J. F.
MAN IN SPACE, Air Force, v. 41, no. 3, Mar 58, pp. 109-117, 120-123, 25 figs.

A review is presented of (1) the battery of psychological testings which volunteer airman, Donald G. Farrell, underwent in a U. S. Air Force space-cabin mock-up, and (2) of a multi-g acceleration experiment carried out by Colonel John Stapp, in which effects of high-speed blastoff were duplicated. The results are interpreted as showing surprisingly high human tolerance levels. A state of weightlessness could so far be produced experimentally for short intervals only, but results indicate that proper training in and orientation about conditions of weightlessness would enhance human performance during zero gravity. The use of such items as padded "highchairs" for seats, squeeze tubes for feeding, and suction-cupped shoes for walking is recommended. The creation of artificial gravity by means of rotation of the craft is considered less desirable for combating weightlessness problems. To meet the oxygen requirements of space man, a closed biological cycle system is recommended. Such a system would be a necessary requirement on long space flights and may solve the problems of space-flight feeding and of human waste disposal. Hazards imposed by cosmic radiation and meteorites have still to be coped with, and certain psychological problems, such as the effects of a "feeling of detachment" on a space traveler, have not as yet been solved. It is predicted that the North American X-15, which is to be launched in 1959, will reveal a great number of data on heretofore unanswered questions. Its pilots will face longer periods of zero gravity and will be compelled to make quick decisions under near-zero-gravity conditions. They will be exposed to speeds of from Mach 5 to Mach 7. The operational range of the X-15 is expected to be about 450 miles. In conclusion, the author presents some speculative ideas concerning the construction of space stations, lunar trips from these stations, and, eventually, trips to some of the planets, such as Mars and Venus.

112. Flickinger, D.
ZERO GRAVITY EFFECTS LARGELY UNKNOWN, Aviation Week, v. 70, no. 1, Jan 59, pp. 35-39.

This is one part of a survey on the ability of man to function usefully in the weightless state. Existing data on this and other bio-medical aspects of space flight are reviewed briefly and discussed in terms of physiological effects and indications for new types of equipment. The physiological parameters include motion sickness, gastrointestinal problems, and skeletal muscle activity problems. Types of equipment needed include all manner of devices for simulators and trainers plus those for food storage and dispensing.

113. FROM THOUGHT TO REALITY (BIO-MEDICAL PROBLEMS OF COSMIC FLIGHT) OT MECHTY K DRISTVITEL'NOSTI (MEDIKO-BIOLOGICHESKIE PROBLEMY KOSMICHESKOGO POLETA) , Voenno-Med. Zhur. (Moscow), 1961, no. 5, pp. 3-9, (in Russian). Also in; Military Med. J. (USSR), 1961, no. 5, pp. 3-12, Also as; U. S. Joint Publ. Research Serv., Washington, D. C., Trans. no. 10052 (1374-N/42), 31 Aug 61.

Scientific preparations leading to the man-in-orbit satellite flight on 12 Apr 61, are discussed in detail. Rocket and satellite flights carrying biological materials were used to work out problems associated with flight dynamics (g-forces, noise, vibration, weightlessness), problems stemming from the physical characteristics of outer space (cosmic radiation, meteors, temperature changes, lack of atmosphere), and problems associated with the internal cabin environment (microclimate, isolation, diurnal rhythm disturbances). Results were satisfactory and information on optimum conditions for space flight. In regard to cosmic radiation, acceleration growth and germination were shown for onion and Nigella seeds after flight, as well as an increase in the frequency of chromosomal aberations in root cells, bone marrow cells of mice, and growth points of plants. Also the frequency of dominant and recessive lethal factors in Drosophila was increased after a 24-hour satellite flight. Isolation and weightlessness proved to be lesser problems. A complete ecological cycle simulating conditions on earth is envisioned for longer space flights with a larger crew.

114. Fukuda, K.
THE EFFECTS OF VARIATIONS IN GRAVITY ON THE MUSCLE TONE (JURYOKU NO HENKA GA KINKINCHO NI OYOBOSU EIKYO) (Abstract), by K. Fukuda, T. Tokida, S. Aoki and T. Takeuchi, Proceedings of the Japanese Society of Aviation Medicine and Psychology (Nihon Koku Igaku Shinri-Gakkai Kiroku) (Tokyo), no. 7, May 59, p. 3, (in Japanese).

The effects of gravitational changes on the tonic labyrinthine reflex in animals were studied. Animals subjected to deceleration, free fall, and motion along a Keplerian trajectory were observed. The effects of an increase in the gravitational forces were studied employing linear and rotational acceleration. The results show that labyrinthine control neck muscle tonus is affected by changes in gravitational forces, and that the rotation and flexion reflex of the neck subsequent to unilateral labyrinthectomy is abolished under conditions of weightlessness (during free fall, Keplerian trajectory) to the point of being difficult to observe.

115. Gantz, K. F., Ed.
MAN IN SPACE. The United States Air Force Program for Developing the Spacecraft Crew. New York. Duell, Sloan and Pearce, 1959. 303 pp.

Contents include:

Ogle, D. C.,	"The Threshold of Space"
Strughold, H.,	"From Aviation Medicine to Space Medicine"
Strughold, H.,	"Basic Factors in Manned Space Operations"
Flickinger, D.,	"Biomedical Aspects of Space Flight"
Stapp, J. P.,	"Biodynamics of Space Flight"
Clamann, H. G.,	"The Engineered Environment of the Space Vehicle"
Hauty, G. T.,	"Human Performance in Space"
Gerathewohl, S. J.,	"Weightlessness"
Sells, S. B. and C. A. Berry,	"Observations in High-Altitude, Sealed-Cabin Balloon Flight"
Balke, B.,	"Experimental Studies on the Conditioning of Man for Space Crews"
Campbell, P. A.,	"Escape and Survival During Space Operations"
Coltra, E. R.,	"Time Dilation and the Astronaut"
The Editors of AFQR,	"The Spiral Toward Space"
Power, P.,	"Human Factors Support of the X-15 Program"
Flickinger, D.,	"The U. S. Air Force Human Factors Program"
Roushey, A. A.,	"Blueprints for Space"
Hopwood, L. P.,	"The Military Impact of Manned Space Operations"

116. Gatland, K. W.
DESIGN FOR ZERO "G": A MAN-CARRYING ROCKET FOR PHYSIOLOGICAL RESEARCH IN NEAR SPACE. Flight (London), v. 61, 27 Jun 52, pp. 774-775.

The plans for a man-carrying rocket presented by R. A. Smith and H. E. Ross of Great Britain in 1946 are discussed. The rocket, which would be propelled by compressed air and alcohol, would have no tail fins. Its initial thrust would be 60,000 lb., its initial acceleration 9.8 ft/sec^2 (after 110 seconds, the effective acceleration would be 2 g). An automatic device would keep the rocket under control in case the pilot would black out. The essential feature of the missile would be its detachable cabin unit, jettisoned by an automatic compressed-air device shortly before peak altitude would be reached. The cabin would descend by parachute. While outside the effect of the gravitational pull of the earth,

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various degrees of "weight" of the pilot may be attained by an axial spin imparted on the cabin by small peroxide-permanganate motors firing tangentially at right angles to its main axis. The range of the rocket has been calculated to be 200 miles, but 180-190 miles is considered the limit of safety.

117. Gauer, O. H.
"Man Under Gravity-Free Conditions" by O. H. Gauer and H. Haber, chapter VI-G, in; GERMAN AVIATION MEDICINE, WORLD WAR II, Vol. I, Dept. of the Air Force, U. S. Government Printing Office, Washington 25, D. C., 1950.

118. Gauer, O. H., Ed.
GRAVITATIONAL STRESS IN AEROSPACE MEDICINE, Ed. by O. H. Gauer and G. D. Zuidema, Boston, Little, Brown and Company, 1961 278 pp., 5 appens.

Contents include:

Gauer, O. H., "The Physiology of Acceleration," pp. 3-6, fig., 3 refs.
Gauer, O. H., "Historical Aspects of Gravitational Stress," pp. 7-9, 2 figs., 10 refs.
Gauer, O. H., "Definitions: Magnitude, Direction and Time Course of Accelerative Forces," pp. 10-15, 2 figs.
Gauer, O. H., "The Hydrostatic Pressures," pp. 16-27, 7 figs., 14 refs.
Lawton, R. W., "Arterial Blood Pressure Responses to Positive Acceleration in Animals," pp. 28-38, 4 figs., tbl., 16 refs.
Gauer, O. H., "Blood Volume and Gravitational Stress," pp. 39-42, 20 refs.
Gauer, O. H., "The Circulation in Man Under Gravitational Stress and in the Giraffe," pp. 43-45, 2 figs., 2 refs.
Gauer, O. H. and E. W. Salzman, "Reflex Responses of the Circulation," pp. 46-51, fig., 22 refs.
Sicker, H. O., "Effect of Acceleration on the Heart," pp. 52-60, 2 figs., 35 refs.
Gauer, O. H. and S. Bondurant, "Effect of Acceleration on Respiration," pp. 61-69, 3 figs., 4 tbls., 27 refs.
White, W. J., "Visual Performance Under Gravitational Stress," pp. 70-89, 4 tbls., 55 refs.
Brown, J. L., "The Physiology of Acceleration-Performance," pp. 90-114, 5 figs., 77 refs.
Gauer, O. H. and G. D. Zuidema, "The Physiology of Positive Acceleration," pp. 115-133, 6 figs., 2 tbls., 29 refs.
Gauer, O. H., "The Physiology of Negative Acceleration," pp. 134-139, 2 figs., 12 refs.

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Edelberg, R., "The Physiology of Combined Accelerations," pp. 140-149, 2 figs., 12 refs.

Bondurant, S., "Transverse G Prolonged Forward, Backward, and Lateral Acceleration," pp. 150-159, fig., 23 refs.

Hessberg, R. R., Jr., "Escape From High Performance Aircraft," pp. 160-164, fig., 5 refs

Stapp, J. P., "Human Tolerance to Severe, Abrupt Acceleration, pp. 165, 188, 10 figs., 40 refs.

Simons, D. G., "Subgravity and Weightlessness," pp. 189-201, fig., 25 refs.

Zuidema, G. D., "Some Physiological Considerations of Space Flight," pp. 202-210, 20 refs.

Leverett, S. D., Jr., R. U. Whitney and G. D. Zuidema, "Protective Devices Against Acceleration," pp. 211-220, 3 figs., 22 refs.

Bondurant, S., "Straining Maneuvers Which Increase Tolerance to Headward Acceleration," pp. 221-223, fig., 4 refs.

Zuidema, G. D., "Clinical Evaluation of Low G Tolerance," pp. 224-237, 14 refs.

Dixon, F. and J. L. Patterson, Jr., "Determination of Accelerative Forces Acting on Man in Flight and in the Human Centrifuge," pp. 243-256, fig., 3 tbls.

Gauer, O. H., "The Hydrostatic Indifference Level," pp. 257-259, 2 figs.

Lawton, R. W., "The Hydrostatic Pressure in the Arterial Tree," pp. 260-261.

Leverett, S. D., Jr. and G. D. Zuidema, "Standardization of Human Centrifuge Techniques," pp. 263-270, tbl., 8 refs.

119. Gaume, J. G.
EFFECTS OF CHRONIC LUNAR GRAVITY ON HUMAN PHYSIOLOGY, by J. G. Gaume and W. Kuehnegger, Paper presented at the ARS Lunar Missions Meeting, 17-19 Jul 62, Cleveland Ohio, ARS paper no. 2469-62, 43 pp., 31 refs.

The physiological problems arising from prolonged exposure of man to lunar gravity are discussed, and a method is proposed for determining the necessary physical exercises on the moon or in any subgravity state including weightlessness. Certain methods of approximating chronic weightlessness can be used instead of prolonged orbital flight. One such method is water suspension of the body for periods of more than one week; another is prolonged bed rest. In these two experimental environments, certain physiological changes occur with regard to bone and muscle structure, cardiovascular response to stress, gastrointestinal function, and renal function. Bones demineralize, and muscle atrophy, producing a negative nitrogen

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balance. Both minerals and nitrogen, as they are removed from the tissues, are excreted through the kidneys. Medical data from these experiments show that maintenance of function and structural integrity of the subsystems of the body lies in proper exercise of the muscles and bones for the particular state of subgravity or weightlessness. An approach to the design and direction of physical activity for any gravity state, particularly lunar gravity, is based on the work/energy expenditure of bone and muscular activity. The prime purpose of exercise is to supplement the work/energy expenditure under the lunar activities and levels so that the sum of both will equal the work/energy expenditure on earth. This required work/energy balance refers to the individual links and joints of a man model. A variety of exercises may be chosen, as long as they meet the original requirement of making up the daily energy balance per link and joint.

120. Gell, C. F.
LONG TERM WEIGHTLESSNESS: ITS POSSIBLE EFFECT ON CELLULAR METABOLISM, Paper presented at the 1962 Meeting of the Aerospace Medical Assoc., 9-12 Apr 62, Atlantic City, N. J. Abstracted in; Aerospace Med., v. 33, no. 3, Mar 62, pp. 336.

The effect of long-term weightlessness on the metabolic function of cell structures in man have been discussed by physiologists in a casual vein since the early concept of manned space flight. The major interest has been directed to the systemic effects of this stressor as related to its effect on the labyrinth, cardiovascular and skeletal systems. The author believes that there is a possibility of more subtle effects at the cell level which may result in cumulative damage to a man in long-term weightlessness. He also believes that observing cells in a weightless state throughout their life cycle of 36 to 72 hours may reveal conclusively whether occult cell physiologic disturbance exists. Knowledge of the effect of weightlessness at the cell level will, if negative, render assurance of the ability of man to withstand long-term weightlessness. Positive evidence of disturbed cellular metabolic processes will influence space ship design. The author discusses methods of accomplishing this type of study and believes it is necessary to avoid mistakes in related design concepts that may prove extremely expensive in the future.

121. General Dynamics Corp., Convair Astronautics Div., San Diego, Calif.
MAY-JULY PROGRESS REPORT FOR THE COMBINED LABORATORY AND AIRPLANE ZERO-G TEST PROGRAM, Aug. 60.

122. General Electric Co., Santa Barbara, Calif.
SUPPORTING MAN IN SPACE: 1970-1975, by A. B. Nadel, RM 59 TMP-85, 30 Nov 59, 47 pp., 55 refs.

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This report discusses progress in space technology that is expected to take place by 1970 and anticipates several bold adventures into space during the period 1970-1975, such as successful trips to the moon and the beginning of interplanetary travel (Mars, Venus, etc.). Needed requirements and capabilities for such accomplishments are discussed in the following areas: 1) the physical environment - atmosphere, gravitational forces (acceleration and zero g), temperature, and radiation; and 2) acoustic noise and vibration.

123. General Electric Co., Space Sciences Lab., Philadelphia
SEALED ATMOSPHERES AND PSYCHOPHYSIOLOGICAL FACTORS: A BIBLIO-ABSTRACT, by L. Chasen, E. Calabrese and D. Himmelstein, Rept. no. 56GSD 344, 1 Apr 60, AD 238 478, 34 pp., 166 refs.

An annotated bibliography on sealed atmospheres and associated psychophysiological factors including acceleration tolerance, weightlessness, and the psychological effects of prolonged isolation.

124. Gerathewohl, S. J.
COMPARATIVE STUDIES ON ANIMALS AND HUMAN SUBJECTS IN THE GRAVITY-FREE STATE, J. Aviation Med., v. 25, no. 4, Aug 54, pp. 412-419, 7 figs., 21 refs.

A survey of work done on the investigation of weightlessness and the progress made on it during five years of research in the field of space medicine.

125. Gerathewohl, S. J.
"Effects of Gravity-Free State" pp. 73-85, 4 tbls., 32 refs., in; ENVIRONMENTAL EFFECTS ON CONSCIOUSNESS, Ed. by K. E. Schaefer, The Macmillan Co., New York, 146 pp.

The purpose of this paper is to survey the present state of the art, and to draw some conclusions about the effects of weightlessness.

Three critical problem areas are focused on (1) the physical aspects of Zero-G; (2) the human-factor aspect of weightlessness; and (3) the operational implications of these states.

126. Gerathewohl, S. J.
THE LABYRINTHINE POSTURE REFLEX (RIGHTING REFLEX) IN THE CAT DURING WEIGHTLESSNESS, by S. J. Gerathewohl and H. D. Stallings, Jr., J. Aviation Med., v. 28, no. 4, Aug 57, pp. 345-355, 6 figs., 3 tbls., 16 refs., Also in; USAF School of Aviation Medicine, Randolph AFB, Tex., EPITOME OF SPACE MEDICINE, item 36, 1958.

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Experiments on the postural righting reflex were made using (1) four young kittens before the reflex was developed, and (2) four older kittens with the reflex well established. On the ground, the animals were dropped in upside-down position from an altitude of about twenty inches, and later in the air exposed to periods of about twenty to thirty seconds of practical weightlessness. The reflex was studied in T-33 and F-94 aircraft under both blindfold and non-blindfold conditions. The behavior of the cats was recorded on 16 mm. film.

The motion pictures were evaluated by repeatedly watching the film, and by an analysis of the individual frames. On ground, the younger animals fell straight down; the older ones turned upright immediately after release without exception. In the air, the younger kittens floated upside-down during weightlessness; the older ones turned upright at the beginning of the weightless state, but their reflex failed after several exposures. By and large, it was observed that the postural righting reflex of the cat ceased to function after a period of about twenty seconds of practical weightlessness; and that the available visual cues did not affect essentially the reflex pattern.

127. Gerathewohl, S. J.
"On Orientation in the Gravity-Free State" ("Zur Frage der Orientation in Schwerefreien Zustand"), pp. 189-195 (in German), in; SPACE-FLIGHT PROBLEMS (Proceedings of the 4th International Astronautical Congress, 1953, Zurich), Biel, 1954.

The problems of orientation expected to arise in a weightless state are discussed. Photographic records of the behavior of mice during experimental flights in a V-2 rocket and two Aerobee rockets are presented as evidence of the disturbances of labyrinthine functioning. The mice with destroyed labyrinths were less confused and showed better adaptive behavior than the ones with functioning labyrinths. Experiences of the test pilot, S. Crossfield, C. Yeager, and others with reduced gravity in parabolic flights indicate no serious disturbances of orientation as long as visual reference is possible and the individual is securely strapped to his seat. The author suggests that the Weber-Fechner law of the relation between the intensity of sensation and the strength of the stimulus may not hold for conditions of weightlessness, i.e. unnatural stimulus ranges.

128. Gerathewohl, S. J.
PERSONAL EXPERIENCES DURING SHORT PERIODS OF WEIGHTLESSNESS IN JET AIRCRAFT AND ON THE SUBGRAVITY TOWER, Paper presented at the Symposium on Motion Sickness in Weightlessness Research, Mar 60, Wright-Patterson AFB, Ohio.

129. Gerathewohl, S. J.
PERSONAL EXPERIENCES DURING SHORT PERIODS OF WEIGHTLESSNESS REPORTED BY SIXTEEN SUBJECTS, Astronaut. Acta, v. 2, 1956, pp. 203-217, 24 refs., Also in; USAF School of Aviation Med., Randolph AFB, Tex., EPITOME OF SPACE MEDICINE, Item 29.

A series of experiments on weightlessness was conducted using a Lockheed T-33 type aircraft for dives and parabola flights yielding practical weightlessness from 10 to 30 seconds duration. Records of the personal experiences of sixteen subjects during these states were obtained by interviews, pilot reports, and written statement.

130. Gerathwohl, S. J.
PHYSICS AND PSYCHOPHYSICS OF WEIGHTLESSNESS-VISUAL PERCEPTION, J. Aviation Med., v. 23, no. 4, Aug 52, pp. 373-395, 5 figs., 69 refs.

The rationale of this study was an investigation of the problem, whether and how visual perception will be affected during the transition of man in the sub-gravity and zero-gravity states.

131. Gerathewohl, S. J.
PHYSIOLOGICAL AND PSYCHOLOGICAL TOLERANCE TO WEIGHTLESSNESS, Paper presented at the ARS Spring Meeting, 4-6 Apr 57, Washington, D. C., preprint no. 390-57, 17 pp., 3 figs., tbl., 8 refs.

Experiments on weightlessness were conducted using a Lockheed T-33 and F-94 type aircraft for parabolic flights yielding virtual weightlessness from 10 to 40 seconds. The responses of the 47 subjects were highly individualistic and indicated a great variability of the tolerance threshold to physiological and psychological effects. The findings suggest that 22 subjects enjoyed the short abaric condition, and that select personnel can be expected to function properly during prolonged exposure to weightlessness.

132. Gerathewohl, S. J.
RECENT EXPERIMENTS ON SUBGRAVITY AND ZERO-G STRESS, Paper presented at the 31st Annual Meeting, Aerospace Medical Association, May 60, Miami Beach, Fla., Abstracted in; Aerospace Med., v. 31, no. 4, Apr 60, p. 304.

Subgravity and zero-G have long been considered an unfavorable environmental condition. For about one decade, several experimenters in this country and abroad have studied the stress as involved in actual and simulated weightlessness on both animals and man. Since weightlessness actually produces a stressless situation, the immersion method has attracted special attention. In this case, no particular surface

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area has to carry the weight of the body, and the internal stress forces seem to be minimized. Moreover, the remaining stress within the body is isotropic, if the difference in hydrostatic pressure remains small. All this is true within certain limits for the homogenous and non-sensoric part of the organism. Gravity and acceleration changes directly act upon the specific gravireceptors. Stimulation of the vestibular system by angular acceleration will not occur in flight parabolas and orbits, if the subject is at rest, since the rotation of a vehicle around its y-axis does not produce vestibular Coriolis effects. Only rotations of the unrestrained subjects cause extreme disorientation after a few revolutions which, in fact, border on severe cases of vertigo, at times. However, with a visual frame of reference and experience in unrestrained floating, moving, and performing, the weightless condition does not appear to be a serious obstacle to space flight.

133. Gerathewohl, S. J.
SENSOMOTOR PERFORMANCE DURING WEIGHTLESSNESS: EYE-HAND COORDINATION, by S. J. Gerathewohl, H. Strughold and H. D. Stallings, J. Aviation Med., v. 28, no. 2, Apr 57, pp. 7-12, 4 figs., tbl., 5 refs., Also in; USAF School of Aviation Medicine, Randolph AFB, Tex., EPITOME OF SPACE MEDICINE, item 34, 1958.

A series of experiments was performed to study sensomotor performance and adaptation during the weightless condition. Subgravity and zero-gravity states were produced by flying dives at high altitudes in a T-33A type aircraft. The results of a simple aiming test obtained from seven subjects show that eye-hand coordination is moderately disturbed by increased or decreased acceleration. The subjects already adjusted to the situation during the first six exposures to weightlessness.

134. Gerathewohl, S. J.
WEIGHTLESSNESS, Astronautics, v. 2, no. 4, Nov 57, pp. 32-34, 74-75, 3 figs., tbl.

A look at some of the problems involving human exposure and tolerance to weightlessness. Responses of 47 human subjects to short periods of weightlessness are included.

135. Gerathewohl, S. J.
WEIGHTLESSNESS: PROBLEM AND AIR FORCE RESEARCH PROGRAM, AUQR, v. 10, no. 2, Summer 58, pp. 121-141, illus.

136. Gilbert, A. P.
CURRENT STATUS OF ANIMAL AND HUMAN EXPERIMENTATION IN ZERO-GRAVITY FLIGHT (ETAT ACTUEL DE L EXPERIMENTATION ANIMALE ET HUMAINE DANS LE VOL EN GRAVITI NULLE), by A. P. Gilbert, H. Boiteau, C. Jacquemin, J. Fabre and A. Adeline, Medicine Aeronaut. (Paris), v. 13, no. 2, 1958. pp. 177-188. (in French)

Continued

A discussion is presented of current animal and human experiments on weightless flight, and the following conclusions are drawn: Weightlessness in flight does not seem to have any adverse physiological effects, and immediately after return to normal conditions, normal activities are resumed spontaneously. Weightless flights also have demonstrated that behavioral analogies exist between compensatory phenomena following total labyrinthectomy and the effects of conditioning to and training in weightlessness. In both these situations, all clues supplied by the labyrinth, whether abolished or repressed, are compensated by visual ones. However, it is still impossible to predict whether the weightless state, which is well tolerated for one-minute periods, will not, when prolonged, have a deteriorating influence on psychomotor performance.

137. Goff, L. G.
THE EFFECT OF TOTAL IMMERSION AT VARIOUS TEMPERATURES ON OXYGEN UPTAKE AT REST AND DURING EXERCISE, by L. G. Goff, H. F. Bruback, H. Specht and N. Smith, J. Appl. Physiol., v. 9, no. 1, Jul 56, pp. 59-61, 3 figs., 9 refs.

Oxygen uptake was measured on four subjects at rest and during mild exercise in air and in water in the temperature range 29.5 - 36.5°C over 20 minute periods. At comparable temperatures, oxygen consumption and heart rate appeared to be affected to a greater extent by average skin temperature than by immersion per se. Failure to give a normal reduction in heart rate on immersion in water below body temperature may indicate unfitness for tasks involving underwater work.

138. Gougerot, L.
THE WEBER-FECHNER LAW VARIATIONS OF THE APPARENT WEIGHT (LOIS DE WEBER-FECHNER ET VARIATIONS DE LA PESANTEUR APPARENTE), Med. Aeronaut. (France), v. 8, 1953, pp. 119-125.

A consideration of the problem of the sensations produced by variations in apparent weight.

139. Grandpierre, R.
PHYSIOLOGY OF SPACE FLIGHT (PHYSIOLOGIE DU VOL SPATIAL), by R. Grandpierre, F. Violette, R. Loubiere and G. Chatelier, Forces aeriennes francaises, v. 14, no. 159, May 60, pp. 789-823 and v. 14, no. 160, Jun 60, pp. 969-986, Abstracted in; Aerospace Med., v . 31, no. 10, Oct 60, p. 873.

The following subjects are reviewed: Acceleration and deceleration tolerances, weightlessness, radiation, prolonged life in a space cabin, oxygen regeneration, utilization of urine and collection of water vapor, and the nutritional requirements of astronauts.

140. Grant, L. J.
LIFE UNDER LOW GRAVITY CONDITIONS, J. Space Flight, v. 8, no. 8, Oct 56, pp. 3-5.

The low-gravity conditions which will be encountered on space flights, e.g., to the moon, present different problems from those associated with zero gravity First, the dichotomy between mass and weight, nonexistent on the earth, has serious implications for the construction of space suits for exploration on the moon, locomotion of the explorers, and transportation on the moon surface. If low gravity is accompanied by low pressure it will cause an increase in capillary siphonage, evaporation problems due to high vapor pressure and low boiling point, a high rate of evaporation, and poor sound conduction. Several prophylactic measures are suggested to counteract muscular atrophy during a long-term stay at low gravity.

141. Graveline, D. E.
MAINTENANCE OF CARDIOVASCULAR ADAPTABILITY DURING PROLONGED WEIGHTLESSNESS, Paper presented at the 1962 Meeting of the Aerospace Medical Assoc., 9-12 Apr 62, Atlantic City, N. J., Also in; Aerospace Med., v. 33, no 3, Mar 62, pp. 297-302, 6 figs., 3 refs.

It is expected that during prolonged zero gravity because of the absence of hydrostatic pressure influences, special techniques will be necessary to maintain cardiovascular adaptability and provide the orbiting astronaut with optimum tolerance for re-entry stresses. The author has devised a multiple tourniquet approach to intermittenly obstruct venous return from the periphery, simulating the hydrostatic pressure effects of standing and thereby "triggering" compensatory cardiovascular reflexes Following 6-hour periods of water immersion with tourniquet protection, the orthostatic tolerance of 5 subjects was determined and compared with that obtained following previous 6-hour immersion tests with no protection. The results are presented and discussed.

142. Graveline, D. E.
PSYCHOBIOLOGIC EFFECTS OF WATER-IMMERSION-INDUCED HYPODYNAMICS, by D. E. Graveline, B. Bruno, R. E. McKenzie and B. Hartman, Aerospace Med., v. 32, no. 5, May 61, pp. 387-400, 10 figs., 3 tbls., 8 refs.

Utilizing a technique involving whole body immersion in water, a hypodynamic environment was produced in which the normal weight sensations were removed and movement was effortless. This experiment was conducted with one subject for a 7-day period during which time extensive biologic data were collected. There are definite indications that pronounced functional impairment results from prolonged exposure to hypodynamic conditions. Following the period of immersion marked

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changes of cardiovascular reflexes and diminished muscular tone were apparent. Hematologic investigations and extensive biochemical studies on blood and urine show significant changes, and there is a gross disruption of psychomotor effectiveness. In general, this study suggests that during prolonged space flight under true weightless conditions the organism may attain a critical state of deconditioning which will seriously attenuate his tolerance for re-entry stresses and the normal gravitational environment.

143. Graybiel, A.
THE SIGNIFICANCE OF THE VESTIBULAR ORGANS IN THE PROBLEMS POSED BY WEIGHTLESSNESS, Paper presented at the Third International Space Science Symposium and Fifth COSPAR Plenary Meeting, 30 Apr - 9 May 62, Washington, D. C., NASA N62-15219, 18 pp., 37 refs.

An attempt is made to define the symtomatology which may be specifically ascribed to the semicircular canals and to the otolith apparatus or to any interaction between the two; and thus to define canal sickness, otolith sickness, and vestibular sickness. The two force environments discussed are weightlessness and the inertial forces generated in the effort to overcome weightlessness. The two sensory organs involved, collectively termed the vestibular organs, are the semicircular canals which are stimulated by angular and coriolis accelerations, and the otolith apparatus, stimulated by linear accelerations. Evidence is presented that the syndrome canal sickness occurs when the semicircular canals are exposed to unusual patterns of angular accelerations of sufficient magnitude and duration. Cardinal symptons are visual and postural illusions, sweating, nausea and vomiting, somnolence, apathy, and difficulty in walking. A specific syndrome analogous to canal sickness has yet to be ascribed to the otolith apparatus; on the other hand, the otolith apparatus has not been ruled out as a possible cause of symptoms during exposure to zero g. Difficulties are encountered partly because weightlessness has not been simulated under terrestrial conditions. An experimental program is under way with human subjects and squirrel monkeys to determine whether otolith sickness may result from bizarre simulation of these sensory organs under terrestrial conditions.

144. Gurfinkel, V. C.
COORDINATION OF POSTURE AND MOVEMENTS OF MAN IN CONDITIONS OF INCREASED AND DECREASED GRAVITY (KOORDINATSIIA POZQ I DVIZHENII CHELOVEKA V USLOVIIAKH POVYSHENNOI I PONIZHENNOI GRAVITATSII), by V. C. Gurfinkel, P. K. Isakov, V. B. Malkin and V. I. Popov, Biul. Eksperimental Noi Biologii I Med. (Moscow), v. 48, no. 11, Nov 59, pp. 12-18, (in Russian).

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The effect of rapidly alternating phases of increased and decreased gravitational force on motor coordination and posture was studied in seven human subjects. Experiments were conducted in the elevator of Moscow University, which permits changes in gravity ranging from 2 G to 0.3 G within two to three seconds. Positional changes of body and extremities and motor coordination were recorded graphically. Under the experimental conditions no significant disturbances were registered either in coordination of positioning of the body and limbs or in the adequacy of motor performance. The role of the visual analysor in maintaining equilibrium does not increase significantly under conditions of subgravity, as shown by analysis of equilibrium reactions of subjects with their eyes closed or open. It is concluded that a 50 per cent increase or decrease in gravity does not materially affect the system which regulates posture and movement on the basis of proprioceptive afferentation.

H

145. Haber, F.
POSSIBLE METHODS OF PRODUCING THE GRAVITY-FREE STATE FOR MEDICAL RESEARCH, by F. Haber and H. Haber, J. Aviation Med., v. 21, no. 4, Aug 50, pp. 395-400, 5 figs., Also in; EPITOME OF SPACE MEDICINE, item 2, USAF School of Aviation Medicine, Randolph AFB, Tex.

Theoretical considerations as to the procurement of means suitable for studying the medical phenomena associated with the lack of weight.

146. Haber, F.
HUMAN FLIGHT AT THE LIMITS OF THE ATMOSPHERE: G-FORCES AND WEIGHT IN SPACE TRAVEL, J. Brit. Interplanet. Soc., v. 12, 1953, pp. 32-34

This is a general discussion of the problem of body weight with respect to human subjects traveling in rockets to the upper limits of the atmosphere and beyond. In a rocket take-off, the acceleration (and weight) will increase toward the end of the propulsion period. The human body can, for a maximum of 3 minutes, tolerate 11 g in the prone position and 14 g in the supine position. These tolerances will effectively limit the acceleration of a rocket with human cargo. Assuming that the initial stage of rocket flight is achieved with the passengers still in good condition, the problem of weightlessness must next be overcome. It is expected, on the basis of animal experimentation, that no major circulatory disturbances will develop; but there might be some difficulty in orientation and muscular coordination. The effects of prolonged weightlessness, are however, unknown - either with regard to animals or humans.

147. Haber, H.
THE CONCEPT OF WEIGHT IN AVIATION, J. Aviation Med., v. 23, no. 6, Nov 52, pp. 594-596.

For purposes of aviation engineering and medicine, the concept of weight is redefined. The principle of d'Alembert states that the sum of the force of gravity, the force of inertia, and the external forces acting upon a body is zero. The weight of the body is then the resultant external force exerted upon the body by a restraining agent in response to forces of gravity and inertia. Six dynamic situations are illustrated, in which the three forces are represented as vectors.

148. Haber, H.
"Gravity, Inertia, and Weight", pp. 123-136, 5 figs., 9 refs., in; PHYSICS AND MEDICINE OF THE UPPER ATMOSPHERE, Ed. by C. S. White and O. O. Benson, Jr., Albuquerque, Univ. of New Mexico Press, 1952, 611 pp.

To evaluate properly the physiological processes in flight, a new formulation of the concept of weight is required. In reversing and implementing the classical definition of weight (or the force of attraction which the earth exerts on a body, with its direction toward the center of the earth) the following definition is proposed: weight is the resultant external force exerted upon a body by a restraining agent in response to forces of gravitation and inertia. This definition makes it evident that weight of a body is not a constant nor a property of the body but depends upon the dynamic conditions to which the body is subjected (e.g. inertia, drag, or propulsion in an aircraft). On the basis of this definition a formula is developed to determine the weight of a pilot under all conditions of propelled and unpropelled flight. The possibility of prolonged weightlessness is a factor to be counted on in future flight and is going to become an outstanding aviation-medical problem. While no major disturbances in the normal physiological functions (such as digestion, breathing, etc.) are foreseen, normal orientation might be impaired.

149. Haber, H.
PHYSICS AND PSYCHOPHYSICS OF WEIGHTLESSNESS, by H. Haber and S. J. Gerathewohl, J. Aviation Med., v. 22, no. 3, Jun 51, pp. 180-189, 3 figs., 6 refs., Also in; EPITOME OF SPACE MEDICINE, item 14, USAF School of Aviation Medicine, Randolph AFB, Tex.

Paper attempts to delineate some of the physical and psychophysical problems associated with the fact of gravity.

150. Haber, H.
PHYSICS AND PSYCHOPHYSICS OF WEIGHTLESSNESS (PHYSIK UND PSYCHOPHYSIK DER GEWICHTSLOSIGKEIT). Weltraumfahrt (Frankfurt), v. 4, no. 2, 1953, pp. 44-50, (in German).

In an analysis of the effects of weightlessness on the human organism, two possible situations may be assumed: (1) the subject is adapted to g = 1, and (2) the subject adapts himself to g = 0. In the first instance the subject will experience a continuous sensation of falling, while the second condition will give rise to sensations of being lifted upwards. Some of the ensuing sensations will be overcome by the visual sense when observing objects which are stationary in respect to the body. However, if one accepts the validity of Fechner's law for the highly complex sense of gravity, serious consequences may result from the weightless state. Thus the intensity range for sensations from 0 to infinity corresponds to a stimulus range from g = 1 to g = $0^{\infty}0$. However, the intensity range for sensations from 0 to ∞ will correspond to a stimulus range of g = 1 to g = 0. Therefore, in reducing the gravity to zero, the same range of sensations is obtained as in an unlimited increase of acceleration. The sensation of gravity becomes particularly critical when values of g approximate 0. At this point very minor changes in acceleration will result in highly intense sensations. At zero gravity self-induced accelerations through voluntary or forced movements of the organism become critical, because of the intensity of sensations evoked. These sensations are not experienced at normal gravity, since according to Fechner's law normally the small additional accelerations remain below the sensory threshold.

151. Haber, H.
PROBLEMS OF SPACE TRAVEL. Sci. News-Letter, v. 62, no 12, 1952, p. 180.

An analysis of psychological, physiological and physical problems of space travel, presented by the author in an address before the American Society of Mechanical Engineers, is summarized. Meteors constitute a danger above 90 miles; cosmic rays are a health hazard between 13 and 23 miles; and ozone and ultraviolet light require protective measures. Frictional heat and extreme temperature differentials between lighted and shaded parts of the rocket represent an additional problem. Weightlessness in free space merely creates slight physiological disturbances; little is known, however, about the psychological consequences of subgravitational flight.

152. Hanrahan, J. S.
SPACE BIOLOGY: THE HUMAN FACTORS IN SPACE FLIGHT, Ed. by J. S. Hanrahan and D. Bushnell, New York, Basic Books, Inc., 1960, 263 pp., 720 refs.

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A historical survey is presented of the research accomplishments which have led to the present state of advancement in the field of space biology. Consideration is given the following items: (1) man's motivation for space travel; (2) the development of a suitable vehicle (including a discussion of human air pressure needs, the techniques for satisfying these needs within the cabin environment, and means of providing for food, water, and wastes utilization or disposal); (3) the hazards of acceleration and weightlessness (with brief reviews of experiments in the human centrifuge, on the Stapp sled, with anti-g devices such as the Mercury couch and the water capsule, and in rockets and aircraft); and (4) potentially troublesome cosmic and Van Allen radiations. An assessment is made of the philosophical and religious implications of space travel, and of the effects such travel will have upon education, government and politics, and economics. More than 700 references are included.

153. Haviland, R. P.
DESIGNING FOR MAN IN SPACE, Spaceflight, v. 3, no. 5, May 61, pp. 81-85.

Study of the results of a preliminary design investigation for a zero-g manned rocket station. The primary purpose of such a vehicle would be the acclimatization of man to a gravity-free state over a period of time. Operation would be inside the limits of the radiation belt. The design features necessary for the accomplishment of such a mission are discussed and the vehicle layout is described.

154. Hawkes, R.
WEIGHTLESSNESS CRUCIAL SPACEMAN FACTOR, Aviation Week, v. 68, no. 5, 3 Feb 58, pp. 50-51, 53, 55, 57, 6 figs.

Describes work being done at the Aero Medical Field Laboratory's Biodynamics Branch - Holloman AFB, N. Mex.

155. Henry, J. P.
ANIMAL STUDIES OF THE SUBGRAVITY STATE DURING ROCKET FLIGHT, by J. P. Henry, E. R. Ballinger, P. H. Maher and D. G. Simons, J. Aviation Med., v. 23, no. 5, Oct 52, pp. 421-432, 5 figs., tbl., 11 refs.

Pulse, respiration, electrocardiogram and arterial and venous pressures were telemetered from one or more of seven anaesthetized primates in four V-2 and three Aerobee rockets during subgravity periods lasting for two to three minutes.

156. Henry, J. P.
EFFECTS OF WEIGHTLESSNESS IN BALLISTIC AND ORBITAL FLIGHT, by J. P. Henry, W. S. Augerson, R. E. Belleville, W. K. Douglas, M. E. Grunzke, R. S. Johnston, P. C. Laughlin, J. D. Mosely, F. H. Rohles, R. B. Voas and S. C. White, Aerospace Med., v. 33, no. 9, Sep 62, pp. 1056-1068, 5 figs., 50 refs.

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Data on weightlessness from work with aircraft and ballistic and orbiting rocket flights is briefly evaluated and described in relation to the results of the Mercury MR-2, 3, 4, MA-5, 6, and 7 flights. It is concluded that:

(a) A person firmly attached to his work place can carry out complex visual-motor coordination tasks proficiently for prolonged periods.

(b) Orientation is little problem if visual or tactile references are present.

(c) Respiration, digestion, eating and mictruition appear to be unaffected by exposure to the weightless state for periods of hours to days.

(d) Weightlessness does not cause gross changes in the circulation within the course of a few hours and reentry has been tolerated after several days.

157. Henry, J. P.
THE MERCURY ANIMAL PROGRAM, by J. P. Henry and J. D. Mosely, Paper presented at IAS-ARS Joint Natl. Meeting, 13-16 Jun 61, Los Angeles, Calif., Paper no. 61-158-1852, 17 pp.

Discussion of the dynamic considerations of the MR-2 flight, with emphasis on the acceleration history. The Physiological and psychological responses of the subject to the flight stresses are described.

158. Hersey, I.
THEY FLOAT THROUGH THE AIR, Astronautics, v. 4, no. 2, Feb 59, pp. 42-43, fig.

In studying the effects of short periods of zero gravity on human performance and behavior, the Air Force Aero Medical Laboratory, Wright-Patterson Air Force Base, Ohio, has used a Convair C-131B transport plane to permit human subjects to float freely, without restraint of any kind, for weightless periods lasting from 12 to 15 sec. The C-131B provides space a little over 6 ft. high, 10 ft. wide, and about 25 ft. long, and permits study of such problems as human orientation and movement, as well as studies of manipulative performances, under zero-G conditions.

159. Hitchcock, F. A.
SOME CONSIDERATIONS IN REGARD TO THE PHYSIOLOGY OF SPACE FLIGHT, Astronaut. Acta, v. 2, 1956, pp. 20-24.

The physiological stresses that will be encountered in space flight are considered. Exposure to barometric pressures lower than 47 mm Hg (63,000 feet) will produce all of the harmful effects that would occur in a vacuum. Therefore from a physiological viewpoint any flight above 63,000 feet may be considered as space flight. In such flights sealed cabins provided with an air conditioned artificial atmosphere must be

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used. While compressed, liquid or chemical oxygen might be satisfactory for flights of short duration the biological methods of providing such atmospheres is probably the best. Thermal stresses, accelerative forces and cosmic radiation are some of the other factors which must be considered. The physiological responses of living animals to a vacuum are discussed. It is concluded that none of these physiological problems is unsurmountable.

160. Hitchcock, F. A.
SPACE MEDICINE, Modern Med., v. 27, no. 18, 15 Sep 59, pp. 210-218, 222, 226-228.

Early events in the development of space medicine in the United States are mentioned and the functions of the environmental physiologist and the engineer are briefly treated. Before manned space flights finally become a reality, the engineer will have developed three distinct types of space craft (multistaged rocket ships, space station or manned artificial satellite, and the true space craft which never enters the earth's atmosphere) which will be considerably different in structure and function. The types of stress that passengers and crew will experience in each type of space craft will vary extensively. These stresses include: (1) excessive acceleration, (2) extreme heat, (3) weightlessness, (4) composition and pressure of atmosphere, (5) explosive decompression, and (6) supply problems. These stresses are discussed briefly and the relative importance of individual stresses to each of the three proposed space craft is indicated.

161. Holden, G. R.
PHYSIOLOGICAL INSTRUMENTATION SYSTEMS FOR MEASURING PILOT RESPONSE TO STRESS AT HIGH G AND ZERO G, by G. R. Holden, J. R. Smith and H. A. Smedal, Paper presented at 32nd annual meeting, Aerospace Medical Assoc., 24-27 Apr 61, Chicago, Ill., Abstracted in; Aerospace Med., v. 32, no. 3, Mar 61, p. 235.

An airborne physiological instrument system reported in NASA TN D-351 has been modified and additional tests have been made in the University of Southern California and AMAL centrifuges and in an F-104B airplane. These tests covered various levels of acceleration from zero to 8 g. The measurements made were, in part: ECG, blood pressure, pulse wave, respiration rate and volume, and carbon dioxide content of expired air. The data from a three-lead electrocardiograph were recorded, using a unique balanced transistor amplifier. Systolic and diastolic blood pressures were measured using an automatic sequencing occluding arm cuff and microphone stethoscope. Pulse wave on the wrist was obtained with a vasochromograph and a.c. amplifier. Several methods were used to measure respiration rate, and respiration volume was measured with a wedge spirometer. The expired air was analyzed for CO_2 content with

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a very much modified Beckman LB-1 gas analyzer. The quanitative effects of short term periods of zero g on pilot control performance were determined by measuring the tracking accuracy, the equivalent analytical transfer function, and the physiological condition of a subject in the rear seat of an F-104B airplane being flown in a 60-80 second zero-g trajectory. A tracking task played back from a tape recorder was presented to the subject on an oscilloscope. The subject used a sidearm controller to attempt to wipe out his tracking error. A small airborne analog computer computed the simulated airplane's response to the control motion and changed the tracking display accordingly. The experiment was repeated and thus affords a direct comparison with a study of pilot control behavior previously conducted on ground-based simulator and a centrifuge.

162. Horak, J.
RECENT DEVELOPMENTS IN AVIATION MEDICINE, (Abstract), South African Med. J. (Cape Town), v. 34, no. 28, 9 Jul 60, p. 582.

A summary is given of a paper presented at the Staff Scientific Meeting of the South African Institute for Medical Research, held at Johannesburg, on March 8, 1960. The paper dealt with three important factors affecting space flight: (1) the physical environment of space, (2) speed of space vehicles in relation to linear, angular, and radial acceleration; and (3) distances space ships will travel over and away from the earth. The medical problems of space flight were discussed, including weightlessness, spatial disorientation, and the "break-off" phenomenon, and devices to preserve the normal physiological environment were outlined.

163. Howard, P.
PHYSIOLOGICAL PROBLEMS OF SPACE FLIGHT, New Scientist (London), v. 10, no. 231, Apr 61, pp. 106-108.

Major problems of manned space flight, primarily acceleration, weightlessness, and deceleration, are discussed. Most of the data of the physiological effects of acceleration (including tolerance to various directions in which it acts on the body, symptoms created, effects on the circulatory system of increasing its intensity, and how to increase tolerance to increased g-intensity by assuming various body and head positions) have come from centrifuge studies. Knowledge concerning such problems as feeding, drinking, and excreting waste products in the weightless state and the effects of weightlessness on the nervous system has been drawn from carefully controlled parabolic flights in which weightlessness has been produced for about 40 sec. Deceleration has exactly the same properties and physiological effects as acceleration, and the same precautions must be taken to avoid exceeding its limits of tolerance. A discussion dealing with ways of keeping within deceleration limits during re-entry is presented.

164. Humphries, J.
SOME IDEAS IN ASTRONAUTICS, Aeronautics, v. 35, Jan 57, pp. 41-42.

Summaries of papers on solar power for propulsion biological hazards of space flight, and effects of weightlessness presented in the 1956 Congress of the IAF in Rome.

I

165. Iazdovskii, V. I.
POSTURAL REFLEXES OF INTACT ANIMALS UNDER CONDITIONS OF WEIGHTLESSNESS (USTANOVOCHNYI REFLEKS INTAKTNYKH ZHIVOTNYKH V USLOVIIAKH NEVESOMOSTI), by V. I. Iazdovskii, E. M. Iuganov and I. I. Kasian, Izvest. Akad. Nauk S.S.S.R. Ser. Biol. (Moscow), v. 25, no. 5, Sep - Oct 60, pp. 762-767 (in Russian).

The postural reflexes were studied in two white rats and two white mice during a rocket flight involving a sevenfold increase in gravity and a nine-minute period of weightlessness. The animals were enclosed in a sealed cabin of the regenerative type with normal atmospheric conditions. Food and drink were freely accessible. Individual and species differences were shown for motor activity during weightlessness. Within 40-45 seconds of weightlessness the movements of the animals became less discoordinated, slower, and smoother. Although the length of time necessary for full adaptation of postural reflexes to weightlessness cannot be estimated at this time, the first signs of adaptation are manifested after 40-45 seconds.

166. Illinois, Univ., Urbana
SOME OBSERVATIONS ON ORIENTATION AND ILLUSION WHEN EXPOSED TO SUB AND ZERO-GRAVITY, by G. J. D. Schock, unpublished doctorate thesis, 1958.

167. Isakov, P. K.
LIFE IN SPUTNIK, Astronautics, v. 3, no. 2, Feb 58, pp. 38-39, 49-50.

A Russian biologist examines problems involved in keeping a living organism alive in Space and reveals Soviet approaches.

168. Iuganov, E. M.
MUSCLE TONE DURING CONDITIONS OF WEIGHTLESSNESS (O MYSCIECHNOM TONUSE V USLOVIIAKH NEVESOMOSTI), by E. M. Iuganov, I. I. Kasian and V. I. Iazdovskii, Izvest. Akad. Nauk S.S.S.R. Ser. Biol. (Moscow), v. 25, no. 4, Jul - Aug 60, pp. 601-606, (in Russian with English Summary).

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The nature and degree of change in the eye muscle tone of a rabbit was investigated during alternating super- and subgravitational conditions. Movements of the left eye were filmed during rocket flight (with accelerations up to 6.5 g and a weightless period of 5 minutes) from the moment of take-off throughout the flight. Control experiments were done under laboratory conditions employing a centrifuge, whereby the acceleration forces attained were analogous to those in flight. The vertical displacement of the eyeball during flight suggests a decrease of the tonic tension of eye muscles during weightlessness. Displacement of the projection of the visual afterimage into distance during alternating super- and subgravitational states (oculogravic and agravic illusion) is apparently caused by the vertical displacement of the eyes, brought about by reflex stimuli from the otolith apparatus.

J

169. Jacobs, H. L.
ADVANCES IN THE ASTRONAUTICAL SCIENCES, VOLUME 6, Ed. by H. L. Jacobs and E. Burgess, AAS Sixth Annual Meeting, New York, Proceedings, 18-21 Jan 60, Macmillan, New York, 1961, 898 pp.

Contents include:
White, S., D. D. Flickinger, T. V. Helvey, A. Mayo and B. Rowen, "Panel Discussion: Man in Space, When?", pp. 37-69, 22 figs., 5 tbls.

170. Jacobs, H. L.
THE LACK OF BEARING CONTACT AND THE PROBLEM OF WEIGHTLESSNESS: THE EFFECT OF PAST EXPERIENCES ON HUMAN PERFORMANCE ON A FREE-ROTATING, LOW-FRICTION TURNTABLE, Ann. N. Y. Acad. Sci., v. 84, Art. 9, 30 Sep 60, pp. 308-328.

The performance of liberal arts students, swimmers, and engineers in the absence of bearing contact was investigated on a low-friction, oil-bearing turntable. These subjects were selected on the basis of differences in the past experiences and training which were considered relevant to the successful performance of simple tasks in such conditions. Thus, the liberal arts students were classified as naive, none having had courses in physics in high school or college. The swimmers had no formal training in physics, but had experience with the type of arm and leg control of body movements generally applicable to the no-bearing contact situation. The engineering students were classified as conceptually sophisticated, having successfully completed one year of college physics, plus advanced courses in statics and dynamics. They were trained in the principles of mechanics as applied to

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engineering problems, and were familiar with Newton's laws of motion as applicable to both translatory and rotatory motion. Each subject was required to perform the following tasks: (1) in the standing position with the turntable stationary, but free to rotate, to make one complete turn without shifting the feet or jumping; (2) in the standing position with the turntable spinning, to stop the rotation as quickly as possible. A hand-held gyroscope, in the form of a bicycle wheel mounted on a steel bar, was available for use with either task if the subject thought it would be of any help. From the observations of performance and level of understanding of the tasks, it was concluded that (a) college students rapidly learned to perform equally well in this situation; (b) engineering students were not able to make efficient use of their familiarity with mechanics to aid in the performance or understanding of the tasks; and (c) engineering students were able to use their knowledge of mechanics to understand the use of a hand-held gyroscope as a tool in these tasks.

171. Johnson, W. H.
THE IMPORTANCE OF THE OTOLITHS IN DISORIENTATION, by W. H. Johnson and N. B. G. Taylor, Paper presented at 32nd annual meeting, Aerospace Medical Assoc., 24-27 Apr 61, Chicago, Ill., Abstracted in; Aerospace Med., v. 32, no. 3, Mar 61, p. 236.

Other than the oculogravic illusion, little is known of the effects of stimulating the otoliths. It is possible, even probable, that the stimulation of these organs particularly during and subsequent to weightlessness, and during changes in linear acceleration, could produce effects of importance in flight. The lack of knowledge results mainly from the difficulty in the laboratory of stimulating the otoliths without at the same time stimulating the semicircular canals; there is also a scarcity of objective signs of otolithic stimulation. A new laboratory procedure will be described with the aid of moving pictures. Human subjects are exposed to "revolution without rotation," i.e., to a linear acceleration that is continuously changing direction clockwise or counterclockwise. Evidence will be presented that suggests this is an otolithic stimulus causing measurable effects.

172. Johnson, W. H.
THE IMPORTANCE OF THE UTRICLE IN ORIENTATION, Paper presented at the 1959 Meeting of the Aero Medical Assoc., 27-29 Apr 59, Los Angeles, Calif., Abstracted in; Aerospace Med., v. 30, no. 3, Mar 59, p. 189.

The role played by the different components of the non-auditory membraneous labyrinth in spatial orientation merits attention in the field of aviation medicine. Most attention in this regard has been concerned with the activity of the

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semi-circular canals. The otolithic receptors merits special attention because of their apparent stimulation by other types of accelerations which occur during certain types of aircraft maneuvers. The importance of these receptors during the weightless state involving high performance aircraft, rocket flight and orbiting satellites requires elucidation. Difficulty in interpreting the importance of the utricle has been mainly due to lack of confirming experimental evidence. This can be decided most reliably by inactivation of the appropriate branch of the vestibular nerve concerned while leaving the semicircular canals in a functional state. A program designed to enable this type of investigation will be described together with movies showing the reactions of the operated animals when exposed to the gravity free state involving jet aircraft. Control animals were similarly exposed to zero-gravity and differences were noted in the responses of the two types, thus indicating the significance of the otoliths in the perception of gravity.

173. Johnson, W. H.
OBJECTIVE AND SUBJECTIVE MANIFESTATIONS OF CORIOLIS ACCELERATION ON A SLOWLY ROTATING ROOM, by W. H. Johnson, A. Graybiel and J. C. Meek, Paper presented at 33rd annual meeting of the Aerospace Medical Assoc., 9-12 Apr 62, Atlantic City, Abstracted in; Aerospace Med., v. 33, no. 3, Mar 62, p. 340.

The Slow Rotation Room at Pensacola (Aerospace Med., 32: 321-327, 1961) has been used to determine reactions associated with stimulation of the human non-auditory labyrinth. A head-mounted camera has been used to obtain records of eye movements during the vestibular stimulation. These records will be discussed together with other techniques for determining changes in thresholds of vestibular sensitivity. Application to aerospace medicine will be discussed.

174. Johnson, W. H
SOME VESTIBULAR PROBLEMS IN SPACE FLIGHT, Ann. Otol. Rhinol. Laryngol., v. 70, no 3, Sep 61, pp. 777-784, 22 refs.

The present knowledge of the effects of space flight on the nonauditory labyrinth is reviewed. Motion sickness is primarily caused by motion, although there are contributing factors. Whether or not angular acceleration or linear acceleration is the causative motion is debated. The relation of nausea and vomiting to motion sickness is discussed. It is suggested that weightlessness by itself is not nauseating, but that angular acceleration of the head will produce nausea during the weightless state. Vertigo will be a constant hazard during preweightlessness and weightlessness due to rotation of the rocket, tumbling movements of the capsule, and nodding of the head when the trunk rotates in the plane of vehicular rotation.

175. Johnson, S. P.
PLANT GROWTH UNDER NEAR-ZERO GRAVITY, Paper presented at the 1960 Meeting of the Aerospace Medical Assoc., 9-11 May 60, Miami Beach, Fla., Abstracted in; Aerospace Med., v 31, no. 4, Apr 60, pp 308-309

Closed ecological systems of space vehicles or stations will probably make use of algae or broadleaf plants for food and oxygen production. Apparently, plants in general do not have a special requirement for a gravitational field. The algae are largely oriented by the light source. The broadleaf plant above ground is oriented by light in the blue end of the spectrum. Root systems seem to respond more to oxygen tension and moisture levels in soil than to gravitational fields. Several cabinets have been designed to study the plant requirements for gravity. Germinating seeds and plants are illuminated with blue, red and white light from below. Results of these experiments are presented. The problem of moisture supply appears to be a major one. A cabinet has been designed to study this problem. Preliminary studies have shown that pressurized aerosol feeding of the root system overcame the problem of supplying moisture to the root system. However, return of the aerosol spray to the system has not been solved.

176. Jones, E. W.
WHAT DOES "WEIGHTLESSNESS" REALLY MEAN?", Space/Aeronautics, v. 38, no. 5, Oct 62, Pt. I, pp. 65-67, 3 tbls., ref

A short, basic review of the problems of weight and weightlessness in space as they affect human factors as well as equipment design. It analyzes the distinct cases of suborbital, orbital, and escape flight and notes, among other points, that "zero gravity" is really a misnomer.

177. Jain, G.
IS BALANCE AND MOVEMENT POSSIBLE IN A WEIGHTLESS ATMOSPHERE? (L'ÉQUILIBRE ET LES MOUVEMENTS SONT-ILS POSSIBLES EN ATMOSPHÈRE SANS PESANTEUR?), Aviation. Magazine de l'espace (Paris), no. 329, 15 Aug 61, p. 11, (in French)

The state of weightlessness affects conditioned reflexes, the sense of balance and orientation, coordination of movements, and muscular activity. The degree of disorientation varies according to the subject and according to the degree of training.

178. Kasten, D. F.
ANALYSES OF HUMAN MOTIONS IN ORBITAL SPACE, Paper presented at the 1962 Meeting of the Aerospace Medical Assoc., 9-12 Apr 62, Atlantic City, N. J , Abstracted in; Aerospace Med., v. 33, no. 3, Mar 62, p. 341.

A qualitative review is made of some seldom considered human factors problems which may confront a weightless worker in a space environment. Discussions are based on inflight zero gravity research, mathematical analyses of human motion in earth orbits, and computer simulation studies of orbital rendezvous. Topics covered include: human locomotion and rotation in a weightless, frictionless environment; human factors and engineering considerations for the design of rotating space stations; problems involved in tethering a space worker to his vehicle; and some misconceptions about the weightless state. Some implications are suggested for future space efforts.

179. Kennedy, R. S.
A COMPARISON OF SUSCEPTIBILITY TO SYMPTOMS IN THE SLOW ROTATING ROOM (CANAL SICKNESS) AND MOTION SICKNESS IN FLIGHT PERSONNEL, by R. S. Kennedy and A. Graybiel, Paper presented at 32nd annual meeting, Aerospace Medical Assoc., 24-27 Apr 61, Chicago, Ill., Abstracted in; Aerospace Med., v. 32, no. 3, Mar 61, p. 237.

Previous studies have shown that stimulating the semicircular canals in healthy subjects (caused by movements of the head while slowly rotating in a small room) produces symptoms collectively termed "canal sickness." In this experiment susceptibility to canal sickness was measured in three groups of subjects (aviators who had completed military test pilot school, experienced aviators, and incoming flight students) and compared with their susceptibility to other forms of motion sickness and vertigo, as determined by interview and questionnaire. The findings are interpreted in terms of the validity of the test for canal sickness, as a predictor of motion sickness.

180. King, B. G.
PHYSIOLOGICAL EFFECTS OF POSTURAL DISORIENTATION BY TILTING DURING WEIGHTLESSNESS, Aerospace Med., v. 32, no. 2, Feb 61, pp. 137-140, 2 figs., ref

Navy-supported discussion of experiments conducted to test the hypothesis that since only gravity could cause displacement of the utricular otolith in the absence of rotation or movement, no postural response would result by static

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disorientation of the head in the condition of zero gravity. observations on the function of the utricular otolith are presented.

181. Knight, L. A.
AN APPROACH TO THE PHYSIOLOGIC SIMULATION OF THE NULL-GRAVITY STATE, J. Aviation Med., v. 29, no. 4, Apr 58, pp. 283-286, 4 refs.

Discussion of the similarities and differences to be observed between the condition of a body floating in space and that of a body floating in water.

182. Kosmolinskii, F. P.
BIOMEDICAL PROBLEMS OF FLIGHT INTO COSMIC SPACE: A SURVEY OF FOREIGN LITERATURE (MEDIKO-BIOLOGICHESKIE VOPROSY POLETOV V KOSMICHESKOE PROSTRANSTVO. OBZOR INOSTRANOI LITERATURY), Klin. Med. (Moscow), v. 38, no. 5, May 60, pp. 8-12,(in Russian).

This is a review of articles on physiological, psychological, and biological problems of space flight published in the West European and American aviation literature during the last decade.

183. Kousnetzov, A. G.
SOME RESULTS OF BIOLOGICAL EXPERIMENTS IN ROCKETS AND SPUTNIK II, J. Aviation Med., v. 29, no. 11, Nov 58, pp. 781-784, fig.

A discussion is presented of Russian biological experimentation in space flight, as reviewed by A. G. Kousnetzov, chief of the physiology department of the Soviet Air Force Scientific Research Experimental Institute of Aviation Medicine in Moscow, in a paper delivered at the Third European Congress of Aviation Medicine, Louvain, Belgium, in September 1958. Soviet investigations of the effects of space flight on the human organism have been in progress since 1949. In the initial phase, animals encapsulated in hermetically sealed cabins were rocket-flown to heights of 100-210 km. and then ejected for return to earth by parachute. In the second phase, the capsule was eliminated, and the animal (in a special high-altitude suit) was separated by catapult from the descending rocket (at heights of 75-85 km. and of 39-46 km.) and parachuted to earth. The third phase of the experiments culminated in animal-rocket launchings to a height of 473 km. No major physiologic changes that could be regarded as resulting from acceleration, catapult launching, or parachute descent from any of the altitudes studied were observed in the animals. A biological experiment which met all the conditions of space flight was realized with the launching of Sputnik II carrying the dog, Laika. During the crucial period between launching and the time the satellite was placed in orbit, the animal was in such a position as to sustain transverse acceleration. Data about

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the condition and behavior of the animal were successfully transmitted and received. Included was information on the effects of acceleration upon the frequency of heart contractions; the effects of zero-G conditions and weightlessness; the position of the dog's body in space; changes in the functional state of the nervous system; and changes in blood circulation and breathing. No physiologic manifestations of the effects of cosmic radiation on the animal were discovered.

184. Kramer, S. B.
"A Modular Concept for a Multi-Manned Space Station", by S. B. Kramer and R. A. Byers, pp. 36-73, 31 figs., 2 tbls., 24 refs., in; Proceedings of the MANNED SPACE STATIONS SYMPOSIUM, Inst. Aeronautical Sciences, New York, 1960, 322 pp.

Contains a section on the Micro-Ecology which is broken down into the following subsections: Biochemical (Respiratory, Nutritional, Waste); Psychological (Termal, Vibratory and Aurol, Gravitational); External Phenomena (Radiation, Meteors); and Hardware (Micro-Atmosphere System, Equipment Weights plus Power).

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185. Lamb, L. E.
INFLUENCE OF AEROSPACE FLIGHT ON THE NORMAL CARDIOVASCULAR SYSTEM: STRESSES AND EFFECTS, Am. J. Cardiol., v. 6, no. 1, Jul 60, pp. 8-18, 4 figs., 17 refs.

The mechanics of the adjustments and alterations of cardiovascular functions in response to flight stresses such as hypoxia, explosive decompression or acute anoxia, positive pressure breathing, relative immobility, acceleration, decreased barometric pressure, and weightlessness are discussed. Consideration is also given to measures of counteracting the effects of these stresses.

186. Lansberg, M. P.
THE FUNCTION OF THE VESTIBULAR SENSE ORGAN AND THE CONSTRUCTION OF A SATELLITE, Paper presented at the 9th International Astronautical Congress, 25-30 Aug 58, Amsterdam, Holland.

Paper is concerned with the problem of weightlessness which occurs in a satellite. To make a prolonged sojourne in the satellite therefore more physiologic, once again "weight" has to be introduced within the satellite, whereas the satellite itself remains, of course, weightless. This aim can be achieved by making the satellite rotate around its own axis. An acceleration will result acting in a radial direction.

187. Lansberg, M. P.
A PRIMER OF SPACE MEDICINE, Amsterdam, Elsevier Publishing Co., 1960, 165 pp., 34 illus., 210 refs.

A description is presented of the specific medical problems of manned space flight, including the physical, physiological, and psychological aspects and the dynamic conditions of life in a space cabin and man's acceleration tolerance during passage to and from the space station.

188. Lansberg, M. P.
SOME CONSEQUENCES OF WEIGHTLESSNESS AND ARTIFICIAL WEIGHT, J. Brit. Interplanet. Soc., v. 17, no. 9, May-Jun 60, pp. 285-288, 5 figs.

Physiological consequences of weightlessness are discussed. Artificial ventilation will be necessary, because of the absence of convection. In the absence of gravitational clues to position, some disorientation may occur and motor activities may have to be relearned, but muscular atrophy is not likely to be a real hazard. It would be unwise to extrapolate from what is experienced during parabolic flights to what can be expected during semipermanent weightlessness.

Problems raised by rotation of the space vehicle to produce artificial "weight" are also considered, and it is shown that von Braun's proposal for the rotation of a 40 m-radius satellite at an angular velocity of 2radian/sec. is not fully satisfactory physiologically.

189. Lawden, D. F.
THE SIMULATION OF GRAVITY, J. Brit. Interplanet. Soc., v. 16, no. 3, Jul-Sep 57, pp. 134-140, 4 figs.

The artificial gravitational field produced by rotating a spaceship or artificial satellite about its axis is compared and contrasted with normal gravity at the earth's surface.

190. Lawton, R. W.
PHYSIOLOGICAL CONSIDERATIONS RELEVANT TO THE PROBLEM OF PROLONGED WEIGHTLESSNESS: A Review, Astronaut. Sci. Rev., v. 4, no. 1, Jan-Mar 62, pp. 11-18, 31-38, 2 tbls., 167 refs.

In this review speculation is made on some of the possible consequences of long-term weightlessness and methods derived for the prevention of untoward effects. The production of artificial gravity by rotation raises additional problems related to stimulation of the semicircular canals. The present conclusion is that, for a lunar mission of approximately 14 days, the weightless environment will be a requirement and the evidence at hand suggests that man will be able to function adequately if appropriate precautions are taken.

191. Lelievre, J.
A FLIGHT WITH APPARENT ZERO GRAVITY (LE VOL A PESANTEUR APPARENTE NULLE), Information Air, 20 Mar 58, pp. 7-10.

192. Lerine, R. B.
NULL-GRAVITY SIMULATION. Paper presented at the 1960 Meeting of the Aerospace Medical Assoc., 9-11 Mar 60, Miami Beach, Fla., Abstracted in; Aerospace Med., v. 31, no. 4, Apr 60, p. 312.

In a true state of free-fall, cancellation of gravitational and inertial fields results in no tendency for a body to accelerate with respect to its surroundings and in no tendency for the components of the body to accelerate with respect to each other. Although it is not possible to attain such a state in a laboratory at rest with respect to the earth, it is possible to duplicate the effects of weightlessness to varying degrees, and for extended time spans, on a large number of the body functions and sense organs. Success of such simulation depends especially on nullification of visual, mechanoreceptor, and vestibular cues to the gravitational vertical, and also on substantial reduction of any work required of the organism by virtue of its being in an uncompensated gravitational field. An artificial environment for simulation of the null-gravity state, based on the concept of Muller (Science 128; 772, 1958), will be discussed; and a comparison of the physiological and psychological effects of such a simulator with corresponding effects to be expected in true null-gravity will be made for several of the important body senses and functions.

193. Levering, B.
THE CASE OF THE CURIOUS CAT: "LUCKY" FLOATS IN WEIGHTLESS REPOSE AT RANDOLPH'S SCHOOL OF AVIATION MEDICINE, Skyline, v. 14, no. 4, Dec 56, pp. 10-13.

Experiments on weightlessness are becoming increasingly important to aviation as man approaches space flight. Detailed discussions are made of S. J. Gerathewohl's investigations with the cat (Lucky) which are a part of a three-fold research project on weightlessness which he is conducting at the USAF School of Aviation Medicine. Other portions of the program include studies of human tolerance to weightlessness (wherein volunteer subjects experience weightlessness during parabola flights) and visual illusions during zero gravity (wherein subjects are requested to place a pencil dot on targets). Mention is made of several other investigations monitored by Dr. Gerathewohl particularly the "sealed cabin simulator" studies (under the immediate direction of H. Strughold) wherein living conditions during space flights are reproduced as closely as possible.

194. Levine, R. B.
NEW APPROACH TO ZERO GRAVITY TESTS, Aircraft & Missiles, v. 4, no. 6, Jun 61, pp. 26-29.

Lockheed's Null-Gravity Simulator simulates the effects of a space environment by immersing a man in water. Water immersion gives the following desired effects: (1) the subject loses the ability to detect gravitational support, (2) muscular effort for maintaining posture is reduced, (3) previously stretched, soft tissues no longer perceive the direction and magnitude of the gravitational field, (4) the force of friction between the vessel walls and the subject decreases to zero, and (5) hydrostatic pressures in the circulatory system are nearly equaled by the water pressure. By eliminating the action of the otoliths by rotating the entire water chamber, null-gravity simulation is further enhanced. A physical description of the simulator is given. Tests carried out with fish indicate that spinning of humans will produce the desired results, but further tests should be done.

195. Levy, E. Z.
STUDIES IN HUMAN ISOLATION, by E. Z. Levy, G. E. Ruff and V. H. Thaler, J. Am. Med. Assoc., v. 169, 1959, pp. 236-239.

196. Lewis, C.
USAF SCHOOL SIMULATES LIVING IN SPACE, Aviation Week, v. 68, no. 4, 27 Jan 58, pp. 49-61, illus.

Space research projects conducted by SAM in the following areas; space cabin simulation, psychological testing, weightlessness, and photosynthesis.

197. Library of Congress, Aerospace Information Div., Science and Technol. Branch, Washington, D. C.
SOVIET LITERATURE ON LIFE SUPPORT SYSTEMS, Rept. no. AID 61-156, 30 Nov 61, AD 269 794, 10 pp., 17 refs. (OTS $1.60).

198. Library of Congress, Air Information Div., Science and Technol. Section, Washington, D. C.
FURTHER DETAILS ON GAGARIN FLIGHT, AID rept. no. 61-113, 27 Jul 61, AD 261 454, 6 pp., tbl, 5 refs.

Three articles have appeared recently which contain information not found in any of the more than 60 Soviet sources published in connection with Gagarin's flight. The first article was written by Professor G. V. Petrovich and published in the Vestnik of the Academy of Sciences USSR. The second is a TASS interview with Professor V. V. Dobronravov, Doctor of Physical and Mathematical Sciences. The third was written by Inna Yavorskaya, whose title is given as Scientific Secretary of the Interplanetary Travel Commission of the Academy of Sciences USSR. This report recounts certain details found in

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these three articles and discusses their implications. Some of the information presented appears to support certain inferences drawn in previous AID reports.

199. Library of Congress, Air Information Div., Science and Technol. Section, Washington, D. C.
SOVIET RESEARCH ON GRAVITATION: AN ANALYSIS OF PUBLISHED LITERATURE, by M. A. Garbell, Rept. no. AID 60-61, Oct 60, 379 pp.

A correlation is presented of K. P. Stanyukovich's public statements on weightlessness with views expressed by other Soviet-area scientists. A general presentation of the problem of gravitation and the status of Soviet research on gravitation and a correlation of Soviet and Western research is included. The appendix includes a translation of Stanyukovich's "The Problem of the Physical Nature of Gravity".

200. Library of Congress, Science and Technol. Div., Washington D. C.
AEROSPACE MEDICINE AND BIOLOGY: AN ANNOTATED BIBLIOGRAPHY, VOLUME III, 1954 LITERATURE, by A. J. Jacobius, R. Kenk, E. Marrow, I. M. Plavnicks, K. Voulgaris and L. D. Davis, 1960, PB 171 029, 542 pp., 1368 refs.

This bibliography, which was prepared under the sponsorship of the National Aeronautics and Space Administration, of the Advanced Research Project Agency, and of the Defence Research Board of Canada, is the third in a series which is scheduled to be brought up to date under an accelerated program within two and one half years. It comprises comprehensively the monographic, periodical, and report literatures, both domestic and foreign, of the year 1954. The bibliography is arranged alphabetically by authors and contains 1368 abstracts. It includes a secondary author, a corporate author, and a detailed and thoroughly cross-referenced subject index. The indexes, cumulated for Volumes I-III, contain close to 4000 entries. The bibliography covers all subject fields pertinent to aviation and space medicine, particularly the following: physiology, biology, psychology, patnology, pharmacology, toxicology, sanitation, human and operational aspects, engineering, extraterrestrial environments, nutrition, survival and rescue, personnel problems, and accident prevention.

201. Library of Congress, Science and Technol. Div., Washington, D.C.
AEROSPACE MEDICINE AND BIOLOGY: AN ANNOTATED BIBLIOGRAPHY, VOLUME IV, 1955 LITERATURE, by A. J. Jacobius, R. Kenk, L. D. Davis, E. G. Koines, I. M. Plavnicks and K. Voulgaris, 1961, AD 258 191, 330 pp., 1517 refs.

This latest volume of the retrospective part of the bibliography follows in all major respects the preceding issues, as outlined in abstract no. 200 of this series. The 1517 abstracts

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are covered by expanded, cumulated subject and corporate author indexes. Future volumes are scheduled to appear at the rate of two per year until the series is up to date.

202. Library of Congress, Science and Technol. Div., Washington D. C. AEROSPACE MEDICINE AND BIOLOGY: AN ANNOTATED BIBLIOGRAPHY, VOLUME V, 1956 LITERATURE, by A. S. Jacobius, R. Kenk, L. D. Davis, E. G. Koines, K. Pappajohn and I. M. Plavnicks, 1962, 378 pp., 1492 refs.

Abstracts are arranged by subject catagories for greater convenience to the reader desirous to gain information on broad subject matters by quick direct perusal.

203. Library of Congress, Technical Information Div., Washington, D. C.
AVIATION MEDICINE: AN ANNOTATED BIBLIOGRAPHY 1952 LITERATURE, by A. J. Jacobius and M. J. Wilkins, Nov 56, PB 121543, 204 pp., (OTS $4.00).

204. Loftus, J. P.
MOTION SICKNESS DURING A WEIGHTLESS STATE, Paper presented at the Symposium on Motion Sickness in Weightlessness Research, Mar 60, Wright-Patterson AFB, Ohio.

205. Lomonaco, T.
BEHAVIOR OF SOME PERCEPTUAL-MOTOR FUNCTIONS DURING THE TRANSITION FROM ABOUT TWO TO ZERO G AND THE EFFECT OF TRAINING: EXPERIMENTS EXECUTED WITH THE SUBGRAVITY TOWER (COMPORTAMENTO DI ALCUNE FUNZIONI PERCETTIVO-MOTORIE DURANTE IL PASSAGGIO DA CIRCA 2 A 0 G ED INFLUENZA DELL ALLENAMENTO: ESPERIMENTI ESEGUITI CON LA TORRE DI SUBGRAVITA), by T. Lomonaco, A. Scano and F. Rossanigo, Riv. Med. Aeronaut. (Rome), v. 23, no. 4, Oct-Dec 60, pp. 439-456, 10 refs., (in Italian).

Six subjects executed a repetitive task with electrical switches following a pre-established pattern while at rest and when launched on a subgravity tower to alternate states of hyper- and zero gravity. An analysis of films taken during the test showed that normal subjects could tolerate several short and frequent exposures to zero gravity before and after mild rectilinear accelerations without any difficulty, and could perform relatively simple perceptual-motor tasks, although with less speed and accuracy than under normal conditions. Repetition of the task during launches (training) led to a definite improvement in performance. Unrestrained subjects exhibited greater difficulty and inaccuracies in task performance. It was observed from recorded photograms that the greatest part of each test was performed under sub- or zero gravity states. These states only slightly affected the coordinated motor performance of the subject provided that the relation between his body and the surrounding objects remained fixed.

206. Lomonaco, T.
INITIAL STUDIES OF THE PHYSIOPATHOLOGICAL EFFECTS CAUSED BY SUBGRAVITY ON ANIMALS IN ROCKETS (PRIMI STUDI SUGLI EFFETTI FISIOPATOLOGICI CAUSATI DALLA SUBGRAVITA IN ANIMALS LANCIATI, DENTRO MISSILI NELL'ALTA ATMOSFERA), Riv. Med. Aeronaut.(Rome), v. 16, no. 2, Apr-Jun 53, pp. 192-199, 3 figs., (in Italian with English summary).

207. Lomonaco, T.
PHYSIOPATHOLOGY DURING SPACE FLIGHT: MOTOR COORDINATION IN SUBJECTS EXPOSED TO ACCELERATION VALUES VARYING FROM 3 G to 0 G (SULLA FISIAPATOLOGIA DURANTE IL VOLO NELLO SPAZIO: COMPORTAMENTO DELLA COORDINAZIONE MOTORIA IN SOGGETTI SOTTOPOSTI A VALORI DI ACCELERAZIONE VARIANTE DA 3 A ZERO G), by T. Lomonaco et al., Riv. Med. Aeronaut. (Rome), v. 20, 1957, pp. 76-96, v. 20 (1, supplement), Jan-Mar 57, pp. 76-96, (in Italian).

208. Lomonaco, T.
SOME PHYSIO-PSYCHIC EXPERIMENTAL DATA ON THE EFFECTS OF ACCELERATIONS AND SUBGRAVITY PREDICTABLE FOR MAN IN SPACE (ALCUNI DATI SPERIMENTALI FISIO-PSICHICI SUGLI EFFETTI DELLE ACCELERAZIONE E DELIA SUB-GRAVITA PREVISTI NELL'UOMO LANCIATO NELLO SPAZIO), by T. Lomonaco, A. Scano, M. Strollo and F. Rossanigo, Riv. Med. Aeronaut. (Rome), v 20, no. 3, Jul-Sep 57, pp. 363-390, (in Italian with English summary).

209. Lomonaco, T.
VARIATIONS OF PSYCHOPHYSIOLOGICAL DATA IN MAN SUBJECTED TO CHANGES IN ACCELERATIONS BETWEEN 3 AND ZERO G (COMPORTAMENTO DI ALCUNI DATI FISIO-PSICHICI NELL'UOMO SOTTOPOSTO A VARIAZIONI DI ACCELERAZIONE COMPRESE FRA 3 E ZERO G), by T. Lomonaco, A. Scano and F. Rossanigo, Riv. Med. Aeronaut. (Rome), v. 21, no. 4, Oct-Dec 58, pp. 691-704, 4 figs., 15 refs., (in Italian with English summary).

Studies were carried out concerning psychophysiologic effects of weightlessness on human subjects (zero G, after an initial acceleration of 3 G). States of subgravity were achieved by drops from a tower 14-m. high, which is described in detail. The authors made radiograms of the thorax and electronystagmographic recordings during the zero G state. Sensations experienced during the experiment were described by the test subjects upon termination of the experiments. The results show that weightlessness is accompanied by displacement of the heart and the diaphragm. Zero gravity, however, does not induce nystagmus or modify previously induced nystagmus. Among the sensations reported, the feeling of being lifted and of falling into the void was considered unpleasant; some subjects reported loss of the sensation of being tied to the seat. Two subjects who had kept their eyes shut reported that they felt like taking successive upward jumps after the actual fall, which was not perceived as such.

210. Loret, B. J.
OPTIMIZATION OF SPACE-VEHICLE DESIGN WITH RESPECT TO ARTIFICIAL GRAVITY, Paper presented at the 1962 Meeting of the Aerospace Medical Assoc., 9-12 Apr 62, Atlantic City, N. J., Abstracted in; Aerospace Med., v. 33, no. 3, Mar 62, p. 343.

A design envelope and the optimum vehicle configuration are established through a human-factors analysis of the artificial gravity environment peculiar to rotating space vehicles. The envelope is prescribed by: an upper limit on vehicle angular velocity of 0.4 radians/sec to minimize occurrence of "canal sickness"; an upper limit of one "g", and a lower limit of 0.2 g to permit unaided walking, both limits modified to compensate for Coriolis effects; and a practical upper limit on vehicle radius of 180 feet. The optimum configuration is characterized by a single cylindrical crew compartment oriented parallel to the spin axis, counterbalanced by other vehicle components. The configuration is illustrated in the conceptual Pseudo-Geogravitational Vehicle of 180-foot radius, rotated at 0.4 radians/sec to produce 0.9 in the crew compartment.

211. Lovelace, W. R., II
BIOMEDICAL ASPECTS OF ORBITAL FLIGHT, by W. R. Lovelace, II and A. S. Crossfield, Soc. exp. test Pilots, v. III, no. 3, Spring 59, pp. 41-56.

This article discusses the biomedical aspects of the orbiting flight problem. The three types of manned orbital vehicles are described in terms of their potential use in biomedical research. Seven phases of orbit mission are delineated and the biomedical problem areas in each are examined. Four stages of performance degradation are indicated for use as guides to the tolerance that must be built in to obtain an adequate level of functioning of man in the respective phases.

212. Lovelace, W. R., II
SPACE MEDICINE AND THE FUTURE, by W. R. Lovelace, II and A. H. Schwichtenberg, Astronautics, v. 6, Oct 61, pp. 58-59, 98-104.

Discussion that defines some problems in space medicine and indicates their future trends. These problems include ageing; behavioral science; biomedical data collection, processing, and utilization; environmental cycles; safety and reliability; and extraterrestrial life.

213. LUNAR JOURNEY, Lancet (London), v. 1, no. 7134, 21 May 60, pp. 1117-1118.

The physiological problems of orbital and space flight are briefly reviewed, including: (1) the typical aviation

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stresses of acceleration, low barometric pressure, and temperature and humidity extremes, for which adequate measures of protection are available; (2) prolonged weightlessness, the "breakoff phenomenon," and primary cosmic radiation, about which little is known; and (3) problems of lunar flight which will require further development of existing techniques, such as increased acceleration stress, the mental strain of extended flight, the additional radiation hazard of the Van Allen belts, and the necessity for the provision of large quantities of food and oxygen.

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214. MAC "The Problem of Weightlessness", Conquest (Johannesburg), v. 1, no. 3, Nov 57, pp. 4-5.

215. McCutcheon, E. P.
"Aeromedical Studies: B. Physiological Responses of the Astronaut", by E. P. McCutcheon, C. A. Berry, G. F. Kelly, R. M. Rapp and R. Hackworth, pp. 54-62, 3 refs., in; RESULTS OF THE SECOND UNITED STATES MANNED ORBITAL SPACE FLIGHT, MAY 24, 1962, Rept. no. NASA SP-6, Government Printing Office, Washington, D. C., 1962, 107 pp., ($0.65).

The MA-7 mission provided further observation of man's physiological responses to space flight. The stresses of space flight appeared to have been well tolerated. All flight responses are considered to be within acceptable physiological ranges. Specifically, the heart-rate response to nominal exercise demonstrated a reactive cardiovascular system. An aberrant ECG tracing was recorded during reentry and is believed to have resulted from the increased respiratory effort associated with continued speech during maximum acceleration. No disturbing body sensations were reported as a result of weightless flight. Astronaut Carpenter felt that all body functions were normal. Solid foods can be successfully consumed in flight, but precautions must be taken to prevent crumbling. The biosensors provided useful ECG data, with minimal artifact. The respiration rate sensor provided good prelaunch but minimal in-flight coverage. Because of erratic amplifier behavior, the rectal temperature thermister gave invalid values for approximately one-third of the flight. At the present time, the in-flight blood pressure cannot be interpreted.

216. Malcik, V.
PROBLEMS OF SPACE MEDICINE (OTAZKY KOSMICKEHO LEKARSTVI), Tvorba (Prague), v. 26, no. 17, 27 Apr 61, pp. 387-388, (in Czech.), Also as; U. S. Joint Publ. Research Service, Washington, D. C., Trans. no. 4717 (1842-S), 22 Jun 61.

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Some of the physiological problems of space flight are reviewed. Vibrations of high amplitude cause general fatigue, create disturbances of the autonomic nervous system, vision, and hearing. To raise tolerance to acceleration, the space ship may be equipped with an anti-g capsule which rotates, keeping the astronaut transverse to the direction of acceleration. Weightlessness does not interfere with vital functions, e.g., respiration, heart rate, blood pressure, but it has a disturbing effect on coordination of movements and orientation in space. A different composition of the cabin atmosphere from that of earth is considered; it may consist of 60% oxygen, 20% helium, and 20% nitrogen. The high oxygen content will permit reduction of cabin pressure, and together with helium, avert some of the consequences of explosive decompression. Other problems result from the effects of accumulation of carbon dioxide, radiation, isolation, and disturbance of the diurnal rhythm. Sanitation problems to be solved include hygiene of skin and clothing, elimination, and disposal of wastes.

217. Marbarger, J. P., Ed.
SPACE MEDICINE, Symposium at the Professional Colleges of the Univ. of Chicago, 3 Mar 50, Univ. of Illinois Press, Urbana, 1951, 83 pp.

Contents:

Armstrong, H. G., "Space Medicine in the United States Air Force," pp. 11-13.
von Braun, W., "Multi-Stage Rockets and Artificial Satellites," pp. 14-30, 6 figs.
Strughold, H., "Physiological Considerations on the Possibility of Life Under Extraterrestrial Conditions," pp. 31-48, 6 figs., 12 refs.
Haber, H, "Astronomy and Space Medicine," pp. 49-61, 3 figs.
Campbell, P. A., "Orientation in Space," pp. 62-69.
Buettner, K., "Bioclimatology of Manned Rocket Flight," pp. 70-83, 3 figs., 12 refs., appen.

218. Margaria, R.
ACCELERATION FORCES AND THE SUBGRAVITY STATE DURING FLIGHT (LE FORZE DI ACCELERAZIONE E LA CONDIZIONE DI SUBGRAVITA IN VOLO), Riv. Med. Aeronaut. (Rome), v. 20, 1957, pp. 175-186, (in Italian).

219. Margaria, R.
BODY SUSCEPTIBILITY TO HIGH ACCELERATIONS AND TO ZERO GRAVITY CONDITION, by R. Margaria and T. Gualtierotti, Paper presented to Intern. Council Aero. Sci., 2nd Intern. Congress, 12-16 Sep 60, Zurich, 34 pp., 26 refs.

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Discussion of experiments performed on animals in order to investigate possible effects of satellite flight on humans. It is found that fishes and frogs show an impairment of balance only after 2,000 g centripetal acceleration in a centrifuge for 10 min. Such loss of balance is ascribed to the destruction of the otolith system, due to the tearing away of the otoliths from their sensory cells in the inner ear, as evidenced by histological examination of the fish. Frogs show a complete recovery of the sense of balance after 10 to 20 days. A second centrifugation, furthermore, does not impair the recovered sense of balance. Experiments investigating the mechanism of recovery and the origin of this new sense of balance are described. The mechanism of the labyrinth and of the related center in the cerebellar flocculo-nodular lobe are investigated and their response to acceleration is studied. Pigeons, and birds in general, are subjected to changes in acceleration forces acting on their vestibulo-cerebellar system during flight. An electrocerebellogram is recorded under various degrees of stimulation. An analysis of this information shows that responses to static and dynamic stimulation are different. Static excitation induces an increase of amplitude of the cerebellar potentials in some sites of the cerebellum while a decrease is observed in some other, maximum differences resulting from the lateral parts against the medial in the flocculo-nodular lobe. Microelectrode investigation of single units in the flocculo-nodular lobe points to the existence of various kinds of units spread over the cortex. Some of these fire only at static and some at dynamic, and some at both static and dynamic stimulation. The function of the labyrinth organ is studied. The otolith apparatus is not found to be a very fine static instrument; response is absent if the gravitational field is increased by even 50% or more, the direction of the force remaining unchanged.

220. Margaria, R.
SUBGRAVITY AND THE ELIMINATION OF THE EFFECT OF ACCELERATION (LA CONDIZIONE DI SUBGRAVITA E LA SOTTRAZIONI DALL'EFFETTO DELLE ACCELERAZIONI), Riv. Med. Aeronaut., v. 16, no. 4, Oct-Dec 53, pp. 469-474, (in Italian).

A method of creating conditions of subgravity by immersion of the test subject in a fluid of equal specific gravity is discussed. Such an experimental procedure would make superfluous the considerable more complicated and costlier methods in which weightlessness is created by means of free falling bodies. Furthermore, a body immersed in a fluid of equal density does not undergo either gravitational or other types of acceleration. This phenomenon could be applied toward prevention of injuries in airplane crashes, by placing the pilot into a reinforced cockpit immersed in a fluid of a density equal to the pilot's body.

221. Matthews, H. C
SOME FREE FALL EXPERIMENTS. Paper presented at the 20th International Physiological Congress, 30 Jul - 4 Aug 56, Brussels, Belgium

222. Mayo, A. M.
REQUIREMENTS FOR ARTIFICIAL GRAVITY DURING PROLONGED SPACE FLIGHT-IMPACT ON VEHICULAR DESIGN AND OPERATION. Paper presented at the AAS 7th Annual Meeting 16-18 Jan 61, Dallas, Tex., AAS preprint no 61-13, 6 pp.

223. Meek, J. C.
OBSERVATIONS OF CANAL SICKNESS AND ADAPTATION IN CHIMPANZEES AND SQUIRREL MONKEYS IN A "SLOW ROTATING ROOM," by J. C. Meek, A. Graybiel, D. E. Beischer and A. J. Riopelle, Paper presented at 32nd annual meeting, Aerospace Medical Assoc., 24-27 Apr 61, Chicago, Ill., Aerospace Med., v. 33, no. 5 May 62, pp. 571-578, 4 figs., 2 tbls., 4 refs.

Chimpanzees and squirrel monkeys, with both normal and disturbed vestibular function, were subjected to varying degrees of rotation in the Pensacola Slow Rotation Room. The normal animals showed a form of "canal sickness" similar to that observed in normal humans, and adaptation could be observed after exposure of the animals to subcritical stimulation for several days. The manifestations of canal sickness were correlated with labyrinthine function. It was found that canal sickness failed to develop in those animals which exhibited no nystagmus in bi-lateral caloric tests. These experiments point to the conclusion that in these animals as in man, the canal sickness experienced in a slow rotation room depends upon normal vestibular function. Thus the chimpanzee and the squirrel monkey may contribute considerably to the clarification of the etiology and final control of canal sickness.

224. Metzger, C. A.
CREW ACCOMMODATIONS FOR AEROSPACE MISSIONS, by C. A. Metzger and A. B. Hearld, Paper presented at the 1962 Meeting of the Aerospace Medical Assoc., 9-12 Apr 62, Atlantic City, N. J., Abstracted in; Aerospace Med., v. 33, no. 3, Mar 62, p. 345.

The results of research by the Aerospace Medical Laboratory on techniques and devices for crew accommodation for use in a weightless environment, which would exist in an earth-orbiting vehicle, are presented. New and unique methods for storing human wastes, with and without chemical treatment, in sealed containers are described. Specialized techniques for bathing, shaving, oral cleansing, laundering and nail and hair care are reviewed. Gravity-independent procedures for storing, preparing, preserving, and dispensing of foods are presented. The problems of weightlessness and the integration of the accommodations are discussed. Laboratory models of components

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required for food storage and serving, refrigeration, waste collection and disposal, and personal hygiene and sanitation are described. Feasibility of the techniques and experimental devices will be studied in a 3-man 14-day test in a laboratory life support system evaluator.

225. Minkewitzova, D.
FIVE SECONDS IN A WEIGHTLESS STATE, Zapisnik (Prague), v. 3, no. 14, Jul 59, p. 16-17, (in Czechoslovakian).

In a zero-gravity experiment conducted by the Czechoslovak Institute of Aviation Medicine (Ustav leteckeho zdravi) two physicians of the Institute were used as subjects. Electrocardiograms were taken on one of the subjects. Several consecutive zero-gravity experiments, each lasting 5 seconds, were performed from 2,000-meter altitude, using IL-14 aircraft of Czechoslovak make. Normal drinking from a cup or a bottle was impossible in a weightless state. After approximately 30 minutes the aircraft landed and the experiment was completed. Almost all of the members of the test crew were ill and nauseated, including the reporter, who also suffered an extremely severe headache subsequently. The headache was so severe, the reporter asserts, that three different types of headache powders and pills were completely ineffective, in fact she felt as though "someone had scrambled my brains."

226. Minners, H. A.
"Aeromedical Studies: A Clinical Medical Observations," by H. A. Minners, S. C. White, W. K. Douglas, E. C. Knoblock and A. Graybiel, pp. 43-53, 15 refs., in; RESULTS OF THE SECOND UNITED STATES MANNED ORBITAL SPACE FLIGHT, MAY 24, 1962, Rept. no. NASA SP-6, Government Printing Office, Washington, D. C., 1962, 107 pp., ($0.65)

A review of the detailed medical examinations accomplished on two astronauts who each experienced approximately $4\frac{1}{2}$ hours of weightless space flight reveals neither physical nor biochemical evidence of any detrimental effect. Specifically, no pulmonary atelectasis has been found, no cosmic-ray damage has occurred, and no psychiatric abnormalities have been produced. In spite of directed efforts to stimulate the pilot's orientation and balancing mechanisms during weightless flight, no abnormal vestibular nor related gastrointestinal symptoms have occurred. Postflight special labyrinthine tests have confirmed an unchanged integrity of the pilots' vestibular system. Although events occuring during the MA-7 mission permitted only a qualitative verification of gastrointestinal absorption of xylose, such absorption was normal during MA-6. Biochemical analyses after Scott Carpenter's flight confirmed the occurrence of a moderate diuresis. Water survival is an emergent situation requiring the optimum in crew training and procedure discipline. Furthermore, if heat stress continues to be a part of space flight, adequate fluid intake during the mission is necessary for crew performance and safety.

227. Morin, L.
THE PHYSIOLOGY OF SPACE (LA PHYSIOLOGIE DE L'ESPACE), Laval medical (Montreal), v. 32, no. 2, Sep 61, pp. 161-177, (in French).

A general discussion is presented of the physiological effects and ecological problems of space flight. The astronaut in a hermetically sealed cabin will be subjected to weightlessness, accelerations, and decelerations, extreme temperature changes, monotony, noise, vibrations, and to the hazards of meteorites and radiations (Van Allen belt, ultraviolet and cosmic rays).

228. Muller, H. J.
APPROXIMATION TO A GRAVITY-FREE SITUATION FOR THE HUMAN ORGANISM ACHIEVABLE AT MODERATE EXPENSE, Science, v. 128, no. 3327, 3 Oct 58, p. 772, ref.

So far as their effects on the human organism are concerned, the chief peculiarities of weightlessness consist in (i) the cessation of unidirectional stimulation of the vestibular system, together with the sequelae accruing therefrom through reactions of the autonomic and central nervous systems, and (ii) the letting up of the hydrostatic drag on the circulatory system, especially that associated with the erect posture of a man. Both of these peculiarities can be approximated to a considerable degree by a combination of relatively simple devices. The use of these would enable data on the effects of this pseudo-weightlessness, maintained for several hours at least, to be obtained long before the still exceedingly costly direct tests of subjecting human beings to prolonged free fall can be carried out by Western scientists.

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229. National Academy of Sciences - National Research Council, Washington, D. C
THE TRAINING OF ASTRONAUTS. REPORT OF A WORKING GROUP CONFERENCE, Publ. no. 873, 1961, AD 263 763, 118 pp., illus., tbl., 17 refs.

Contents:

Training aspects of the X-15 program.
Man's integration into the Mercury capsule.
Project Mercury astronaut training program.
Some implications of Project Mercury.
Experience for future astronaut training programs.
Dyna-Soar pilot training.

230. National Academy of Sciences - National Research Council, Washington, D. C.
VISUAL PROBLEMS OF SPACE TRAVEL, Ed. by J W. Miller, Apr 62, AD 276 513, 55 pp., 192 refs.

231. National Academy of Sciences - National Research Council, Washington, D. C
ZERO-G DEVICES AND WEIGHTLESSNESS SIMULATORS, by S. J. Gerathewohl, Publ. no. 781, 1961, 143 pp., illus., tbl., refs.,

232. National Aeronautical and Space Administration, Washington,D. C.
PHYSIOLOGICAL SENSORS FOR USE IN PROJECT MERCURY, by C. D. Wheelwright, Rept. no NASA TN D-1082, Aug 62, 37 pp., 20 figs., tbl., 5 refs., (OTS $1.00).

Results of tests of biosensors for measuring body core temperature, respiration rate and depth, and electrocardiogram on animals and humans are presented. Comments are made on the bioconnector and biosensor assembly and the possible use of blood-pressure sensors in space flight.

233. National Aeronautics and Space Administration, Washington,D. C.
PROCEEDINGS OF A CONFERENCE ON RESULTS OF THE FIRST U. S. MANNED SUBORBITAL SPACE FLIGHT, 6 Jun 61, 76 pp., 68 figs., 11 tbls., 15 refs.

Contents include:

Kraft, C. C., Jr., "Flight Plan For The MR-3 Manned Flight,"
Bond, A C., "Mercury Spacecraft Systems,"
White, S. C., "Review of Biomedical Systems For MR-3 Flight,"
Jackson, C. B., Jr., "Results of Preflight and Postflight Medical Examinations,"
Henry, J. P , "Bioinstrumentation in MR-3 Flight,"
Augerson, S., "Physiological Responses of the Astronaut in the MR-3 Flight,"
Slayton, D. K.,"Pilot Training and Preflight Preparation,"
Voas, R. B., J. J. Van Bockel, R. G. Zedekar and P. W. Backer, "Results of In-Flight Pilot Performance,"
Shepard, A. B., Jr., "Pilot's Flight Report, Including In-Flight Films."

234. National Aeronautics and Space Administration, Washington,D. C.
RESULTS OF THE FIRST UNITED STATES MANNED ORBITAL SPACE FLIGHT, FEBRUARY 20, 1962, 204 pp., (U. S. Govt. Printing Office, Washington, D. C. - Price $1 25).

This document presents the results of the first United States manned orbital space flight conducted on February 20, 1962. The prelaunch activities, spacecraft description, flight

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operations, flight data, and postflight analyses presented from a continuation of the information previously published for the two United States manned suborbital space flights conducted on May 5, 1961 and July 21, 1961, respectively, by the National Aeronautics and Space Administration.

235. National Aeronautics and Space Administration. Washington,D. C. RESULTS OF THE PROJECT MERCURY BALLISTIC AND ORBITAL CHIMPANZEE FLIGHTS, Ed. by J. P. Henry and J. D. Mosely, Rept. no. NASA TR-138, (in press).

236. National Aeronautics and Space Administration, Washington,D. C. RESULTS OF THE SECOND UNITED STATES MANNED ORBITAL SPACE FLIGHT, MAY 24, 1962, Rept. no. NASA SP-6, U. S. Govt. Printing Office, Washington, D. C., 1962, 107 pp.

This document presents the results of the second United States manned orbital space flight conducted on May 24, 1962. The performance discussions of the spacecraft and launch systems, the modified mercury network, mission support personnel, and the astronaut, together with analyses of observed space phenomena and the medical aspects of the mission, from a continuation of the information previously published for the United States manned orbital Flight, conducted on February 20, 1962, and the two manned suborbital space flights.

237. National Aeronautics and Space Administration, Washington,D. C. RESULTS OF THE SECOND U. S. MANNED SUBORBITAL SPACE FLIGHT, JULY 21, 1961, 21 Jul 61, AD 270 539, 58 pp., illus., tbls. 8 refs.

Spacecraft and flight plan for the Mercury-Redstone 4 flight; Results of the MR-4 preflight and postflight medical examination conducted on astronaut Virgil I. Grissom; Physiological responses of the astronaut in the MR-4 space flight; Flight surgeon's report for Mercury-Redstone Mission 3 and 4; Results of inflight pilot performance studies for the MR-4 flight; and Pilot's flight report.

238. Naval Air Development Center, Aviation Medical Acceleration Lab., Johnsville, Pa.
THE EFFECTS OF WATER IMMERSION ON PERFORMANCE PROFICIENCY, by R. M. Chambers, D. A. Morway, E. L. Beckman, R. DeForest and K. R. Coburn, Rept. no. NADC-MA-6133, 22 Aug 61, 30 pp., 11 refs.

In an attempt to study a wide range of human performance abilities associated with weightlessness and the transition from weightlessness to high G reentry environment, the technique of water immersion and centrifugation was used to simulate these conditions. Six male subjects were immersed in water to the neck level for a 12-hour period and one subject for a 23-hour period. Eight selected performance tasks were

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administered: (1) before immersion, (2) during immersion, (3) after immersion and centrifugation so that gross motor and perceptual behavior could be sampled. It was found that behavior was not apparently affected by prolonged water immersion followed by reentry type accelerations.

239 Naval Air Development Center, Aviation Medical Acceleration Lab., Johnsville, Pa.
EFFECTS OF WEIGHTLESSNESS AS SIMULATED BY TOTAL BODY IMMERSION UPON HUMAN RESPONSE TO POSITIVE ACCELERATION, by V. G. Venson, E. L. Beckman, K. R. Coburn and R. M. Chambers, Rept. no. NADC-MA-6132, 26 Jun 61, AD 212 329, 14 pp., 3 figs., 5 tbls., 5 refs., Also in; Aerospace Med., v. 33, no. 2, Feb 62, pp 198-203.

Twelve members of Underwater Demolition Team No. 21 used underwater breathing equipment while completely immersed in water for 18 hours. Their response to positive acceleration was determined by observing the G level at which the limitation of ocular motility under acceleration (LOMA) occurred. This G level is approximately the same as when loss of peripheral vision or greyout occurs when subjects are exposed to positive acceleration. The period of immersion was well-tolerated A small but statistically significant decrease in the G level at which LOMA occurred was found following the period of immersion.

240. Naval Air Development Center, Aviation Medical Acceleration Lab., Johnsville, Pa.
LEVER DISPLACEMENT DURING CONTINUOUS REINFORCEMENT AND DURING A "DISCRIMINATION", by R. M. Herrick, Rept. no. NADC-MA-6209, 23 Jul 62, NASA N62-14832, 22 pp., 9 refs.

Measures of the normal motor behavior of animals are required as a basis for evaluating the influence of zero g or above-normal g on motor behavior. The displacement of the T-bar handle of a response lever was categorized into eight intervals, or lever positions, each successively-numbered position representing about 5.10° (or 4.5 mm) of arc. For each lever press by a rat, the maximum displacement of the T-bar was measured under (a) continuous reinforcement and (b) alternating variable-duration periods of continuous reinforcement (S^D) and extinction ($S\Delta$) with a light cue associated with the alternations. Under (a) the mean lever displacement and variability decreased with training. Under (b) the S^D lever displacement distributions differed from their associated $S\Delta$ distributions from the start. The differences increased with daily sessions. Compared with (a), a further decrease in both displacement and variability occurred in S^D. In $S\Delta$, the mean displacement and variability increased and remained at a higher level. A discrimination developed in which 95% of all presses were made S^D. Although decreased motivation reduced the rate of lever-pressing, it had negligible effects on the distance the lever was pressed.

241. Naval Air Development Center, Aviation Medical Acceleration Lab., Johnsville, Pa.
SOME PHYSIOLOGICAL CHANGES OBSERVED IN HUMAN SUBJECTS DURING ZERO G SIMULATION BY IMMERSION IN WATER UP TO NECK LEVEL, by E. L. Beckman, K. R. Coburn, R. M. Chambers, R. E. DeForest, W. S. Augerson and V. G. Benson, Rept. no. MA-6107, 10 Apr 61, AD 256 727, 25 pp., 5 figs., 4 tbls., 11 refs., 2 appens., Also in; Aerospace Med., v. 32, Nov. 61, pp. 1031-1041.

Knowledge relative to the effects of prolonged weightlessness is needed in preparing man for space flight. The buoyant force exerted upon immersed bodies effectively simulates the weightless state with respect to proprioceptive sensory responses and perhaps in other ways. An investigation into the physiological effects of immersing subjects in water up to neck level was undertaken. It was found that water immersion produces an unnatural physiological situation in that, during respiration, the inspired air inflates the lungs to atmospheric pressure while the external pressure against the chest, abdomen, and legs, due to the water, is greater than atmospheric. This situation is equivalent to "negative pressure breathing". A series of experiments involving 7 subjects immersed in water up to neck level for periods of 5 to 23 hours (5 subjects for 12 hours) showed a significant weight loss during the period of immersion, which was explained by the diuresis which occurred. Pulmonary volume measurements showed a decrease in the expiratory reserve volume and in the respiratory minute volume.

242. Naval Air Development Center, Aviation Medical Acceleration Lab., Johnsville, Pa.
WEIGHTLESSNESS SIMULATION BY TOTAL BODY IMMERSION: PHYSIOLOGICAL EFFECTS, by V. G. Benson, E. L. Beckman, K. R. Coburn and R. E. DeForest, Rept. no. NADC-MA-6134, 17 Aug 61, AD 236 194, 20 pp., 4 figs, 7 tbls., 5 refs.

In future manned space flights, the pilot will be exposed to a period of weightlessness between takeoff and reentry into the earth's atmosphere. In planning for these flights information is needed as to the physiological changes which will occur as a result of the weightless period which may alter the capability of the pilot to withstand the acceleration forces imposed on him during the reentry portion of the flight. Attempts have been made to simulate this weightless state by immersing subjects in water up to the neck level for varying periods of time. These subjects were exposed to acceleration forces on human centrifuges before and after water immersion. A reduction in the ability to withstand these acceleration forces was noted following the immersion period. Immersion in water to the neck level produces a negative pressure breathing situation which in turn results in profuse diuresis. These two conditions alter physiology in a manner which would not be applicable to the true weightless state and may have accounted

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for the reduced capability of the subject to withstand acceleration forces following a period of water immersion. In this series of experiments an attempt was made to eliminate the negative pressure breathing and the diuresis by equipping the subject with a full face diving mask with a compensating regulator and completely immersing him in water for a period of twelve hours. The ability to withstand acceleration forces was measured prior to and following the water immersion period. Physiological and psychological changes that occurred as a result of the water immersion were also measured. Of the seven subjects tested, only three were able to tolerate the 12-hour period of water immersion. The remaining four terminated early in the study due to the stress of the underwater environment and were not exposed to acceleration forces following their immersion periods. Of the three who completed the study, two did not show any reduction in their ability to withstand the same acceleration forces following the period of water immersion, however, one was rendered unconscious by the same acceleration force he was able to withstand prior to the immersion period. Due to the small size of the water tank the subjects were in the sitting position during periods of psychological testing and also while watching television. This position resulted in a negative pressure breathing situation with the resultant profuse diuresis.

243. Naval Air Material Center, Air Crew Equipment Lab., Philadelphia, Pa.
ENVIRONMENTAL REQUIREMENTS OF SEALED CABINS FOR SPACE AND ORBITAL FLIGHTS. A BIBLIOGRAPHY OF PSYCHO-PHYSIOLOGICAL STUDIES RELEVANT TO SPACE AND ORBITAL FLIGHT, by N. M. Burns, and R. B. Ziegler, Rept. no. NAMC-ACEL-441, 26 Oct 60, AD 246 414, 1 v.

A bibliography is presented of psychological, physiological and environmental reports pertinent to man's role in space and orbital flight. Five hundred and eighty-two entries are provided on 3 x 5 inch file card forms with the content of the report indicated by the category into which it is placed. The literature review for this bibliography was completed in April 1960.

244. Naval School of Aviation Medicine, Pensacola, Fla.
ANIMALS AND MAN IN SPACE A CHRONOLOGY AND ANNOTATED BIBLIOGRAPHY THROUGH THE YEAR 1960, by D. E. Beischer and A. R. Fregly, Monograph no. 5, ONR rept. no. ACR-64, 1962, 97 pp., tbls., refs.

This work brings together for the first time a listing of all available reports relating to biological experiments conducted during balloon and rocket flights, with plants, animals, and humans as subjects. This compilation includes a listing of pertinent bibliographies, monographs, technical publications,

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and periodical articles. Detailed tabulations are given of all known balloon and rocket flights, including such information as flight designation, location, type of experiment, experimental subjects, height, duration, success or failure, investigators, and cross-references to literature. A selective subject index is included, listing experimental material and giving cross-references to literature. Most of the citations are annotated.

245. Naval School of Aviation Medicine, Pensacola, Fla.
COMPREHENSIVE BIBLIOGRAPHY OF RESEARCH REPORTS ISSUED OVER A NINETEEN-YEAR PERIOD BY THE U. S. NAVAL SCHOOL OF AVIATION MEDICINE, by G. A. Daniel and C. F. Kasparek, Proj. MR005.13-3001, Subtask 5, Rept. no. 3, 1 May 61, 74 pp.

The 772 reports listed cover many aspects and phases of aviation and space medicine and show the trend which research has taken since formal entrance of the School into the field of research in 1942.

246. Naval School of Aviation Medicine, Pensacola, Fla.
HUMAN PERFORMANCE DURING ADAPTATION TO STRESS IN THE PENSACOLA SLOW ROTATION ROOM, by B. Clark and A. Graybiel, Proj. MR 005.13-6001, Subtask 1, Rept. no. 52, 18 May 60, AD 244 935, 25 pp., 4 figs., tbl., 9 refs., Also in; Aerospace Med., v. 32, no. 2, Feb 61, pp. 93-106.

Tests of performance on simple motor tasks were conducted on five normal subjects and on one subject with no vestibular function during and after rotation in a centrifuge room for two days at speeds from 1.71 to 10 r.p.m. Insignificant changes in performance were observed in the subject with bilateral destruction of the inner ears. The most prominent change in performance of normal subjects was in motivation toward toward the tasks; when symptoms of canal sickness were reduced, however, most tests were performed adequately. Performance on tests of walking and body steadiness decreased substantially during and immediately after rotation. No significant decrement in performance was observed for strength of grip, ball throwing, dart tossing, hand steadiness, card sorting, and dial setting.

247. Naval School of Aviation Medicine, Pensacola, Fla.
A NOTE ON THE GRAVITY-FREE STATE ON A SPACE PLATFORM, by J. J. Schaefer, Proj. MR005.13-6001, Subtask 1, Rept. no. 48, 29 Jan 59, AD 213 439, 26 pp., 8 figs.

In an orbiting satellite of finite size, the completely gravity-free state, i.e., full balance of the centrifugal and gravitational force, is realized only in the center of gravity of the vehicle. At points radially inward or outward of this center, small gravitational forces are felt. They are of the

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order of 10^{-6} G and therefore entirely negligible as far as physiological and sensory effects on man are concerned. They are not negligible, however, as soon as free motions of objects on a time scale of several minutes are involved.

Through the use of a concrete example of intersatellite transportation, the dynamics and kinetics of such motions are analyzed in a simplified way. If the satellite is assumed to maintain attitude in space and if the free motions are described in a coordinate system at rest to the satellite, it is found that these motions are rectilinear and of constant speed during an initial period which, for on earth circling vehicle at 500 kilometers altitude, equals five minutes. Thereafter, the apparent motion follows a complicated circular or spiral pattern depending on the direction of the initial speed. Two limiting cases, the "forward" and the "upward" throw of an object from the satellite, are analyzed in more detail.

A consequence of more general interest of these relationships is the known fact that it is not possible to put a loose assembly of parts or objects in orbit so that they maintain their original array. As their respective centers of gravity will have slightly different distances from the center of the earth, they will start spreading as soon as they are set free. On the other side, only very small conservative forces are required to keep even very "heavy" objects aligned.

248. Naval School of Aviation Medicine, Pensacola, Fla.
SYMPTOMS RESULTING FROM PROLONGED IMMERSION IN WATER: THE PROBLEM OF ZERO G ASTHENIA, by A. Graybiel and B. Clark, Proj. MR005.15-2001, Subtask 1, Rept. no. 4, 15 Jul 60, AD 244 932, 27 pp., 3 figs., 6 tbls., 28 refs., Also in; Aerospace Med., v. 32, no. 3, Mar 61, pp. 181-196.

In order to reduce the effects of G on the body, three subjects were floated in tanks of physiological saline solution for ten hours per day for two weeks while systematic attempts were made to eliminate any effects of sensory deprivation. Tests of cardiovascular function and muscular strength and coordination were given before, during, and after the experiment. The results indicated little or no systematic change in the tests of muscular strength and coordination, but all three subjects showed marked postural hypotension on the tilt-table during and following the period of immersion. These results are discussed in terms of possible implications for space flight.

249. Naval School of Aviation Medicine, Pensacola, Fla.
THRESHOLDS OF STIMULATION OF THE OTOLITH ORGANS AS INDICATED BY THE OCULOGRAVIC ILLUSION, by A. Graybiel and J. L. Patterson, Proj. MR005.13-6001, Subtask 1, Rept. no. 38, 26 Jul 54, AD 44 402, 11 pp., 8 figs., tbl., 9 refs., Also in: J. Appl. Physiol., v. 7, 1955, pp. 666-670.

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The oculogravic illusion was utilized as an indicator mechanism in determining the perceptual thresholds of change in the direction of resultant force; this force, the vectorial sum of the forces of gravity and acceleration in a human centrifuge, is expressed by the angle (ϕ) it makes with the gravitational vertical. The mean threshold for 3 subjects in the sitting position was 0.000344 g (ϕ = 1.5) for the 75% correct response level. Corresponding values for the subjects lying on their right sides were 8.9 , and the curve of threshold responses was bimodal. Curves of the threshold values of subjects in an upside-down position resembled the initial portion of the curve obtained with the subjects lying. The findings supported the hypothesis that the otolith organ functions best with the head upright and fails to function with the head down.

250. =Netherlands Armed Services Technical Documentation and Information Centre, Den Haag, The Netherlands.
UNITERMS: SPACE FLIGHT MEDICINE, by J. van Woerden, UDC: 613.693:629.19, TDCK 16903, Feb 59, 45 pp.

This bibliography on space medicine contains summaries of reports and articles compiled from the abstract card indices of the Netherlands Armed Services Technical Documentation and Information Centre. Some of the reports are available on loan from the Centre. The index indicates wide coverage of factors related to space travel from biological and physiological to psychological variables; design of vehicles and suits, radiological problems of space flight, etc. One hundred eight abstracts are included. A majority are in English, but some are in German or Dutch.

251. New, G. W.
YOU'RE IN SPACE, Air Training, v. 4, no. 6, Jan 55, pp. 24-25.

A test pilot's subjective experiences in ascending to higher than 85,000 ft. altitude are described. The sensations during a brief period of weightlessness included falling, difficulty in orienting and spinning.

252. Northrop Corp., Astro Systems and Research Labs., Hawthorne, Calif.
ZERO G FACILITY, by R. Lepper, Rept. no. TM 60-182-3, Jul 60.

253. NUTRITION IN SPACE, Nutrition Revs., v. 18, no. 11, Nov 60, pp. 325-329.

The present state of research on the nutritional problems of space travel is reviewed. Consideration is given to such subjects as the development of regenerative systems; the digestibility, toxicity, and general acceptability of algae as food; eating patterns and food preferences during extended periods of isolation; feeding programs during balloon trials

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(which provide short-term situations comparable to manned space flight); and the development of concentrated, synthetic diets for space travelers. The effects of such stresses as acceleration, deceleration, weightlessness, noise and vibration, and space radiation upon food supplies and food intake are also discussed.

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254 OFFICIAL ACCOUNT OF TITOV'S SPACE FLIGHT (LA RELAZIONE UFFICIALE SUL VOLO SPAZIALE DI TITOV), Oltre il cielo (Rome), v. 5, no. 90, 1-15 Oct 61, pp. 292-296, (in Italian).

The successful launching into space of the spaceship-sputnik "Vostok 2" on August 6, 1961, was manned by the Soviet astronaut, Gherman Stefanovic Titov. The flight lasted 25 hours and 18 minutes. Discussion is presented on the spaceship's structure and equipment; means of radio- and telecommunication; direct television and motion picture recording of the astronaut's behavior during the flight, monitored simultaneously with registrations of physiological functions back to earth; environmental conditions on board (temperature, barometric pressure, etc.); the weightlessness encountered during the flight and its effects on blood circulation, respiration, work capacity, and vestibular apparatus; radiation protection; and the astronaut's impressions of the flight.

255. Ogle, D. C.
MAN IN SPACE VEHICLE, U. S. Armed Forces Med. J., v. 8, no. 11, Nov 57, pp. 1561-1570, 10 refs.

Discusses the hazards of the upper atmosphere and the physiological forces acting on man during a flight in space.

256. Operations Research, Inc., Silver Spring, Md.
WEIGHTLESSNESS, TRAINING REQUIREMENTS AND SOLUTIONS, by B. G. King, C. T. Patch and P. G. Shinkman, Contr. N61339-560, Rept. no. NAVTRADEVCEN 560-1, 3 Mar 61, AD 259 512, 102 pp., illus., tbls.

Physical principles and biological mechanisms relevant to human performance under conditions of weightlessness have been explained in order that the trainee can develop an appreciation of how the unaccustomed environment will affect his behavior. Special emphasis has been given to (a) changes of a man's center of mass as various parts of the body are moved with respect to each other, and the significance of CM of body movement, (b) the mechanisms of postural reflexes including experimental observations of response of pigeons to postural disorientation by tilting during weightlessness, and (c)

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anticipated changes in the sensory input spectrum and implications of such changes. Models have been proposed as visual aids in providing for cognitive learning aspects of training. The different effects of weightlessness on motor-perceptual and perceptual factors have been identified and solutions proposed for separately training each of these effects.

257. Otto, E.
SIMULATION OF ZERO-G AIRCRAFT CONTROL, by E. Otto and T. R. ThorKelson, Instrum. Control Syst. (USA), v. 33, no. 9, Sep 60, pp. 1564-1567.

258. OUTWARD BOUND, Time, v. 71, no. 21, 26 May 58, pp. 68-78, 17 figs.

A brief pictorial review of the psychophysiological factors that man must face during space flight.

259. Ozolins, G.
MAN IN SPACE (CILVĒKS PASAULES TELPA), by G. Ozolins and V. Pelipeiko, Astronomiskais kalendars 1960 gadam (Rīga), v. 8, pp. 102-112, (in Latvian).

This is a status report of the progress made towards space flight in the past year. Findings from laboratory experiments, rocket flights, and artificial satellites are briefly summarized in regard to the biological effects of weightlessness, g-forces, dysbarism, oxygen regeneration, etc. It is suggested that the gas exchange cycle may be better maintained by an artificial atmosphere of an oxygen-helium mixture, wherein nitrogen is replaced by helium. Among the problems raised are (1) the importance of maintaining the diurnal cycle on longer flights, (2) the movement of air within the cabin, and (3) the possible reaction of the human organism to the lack of rare gases in the cabin atmosphere.

P

260. Pace, N.
PROBLEMS IN SPACE PHYSIOLOGY, Publ. Astronaut. Soc. Pacific, v. 70, no. 415, Aug 58, pp. 349-359, 11 refs.

A review of the problems of air content and pressure, food and water, waste disposal, radiation, g tolerance, and weightlessness.

261. Page, W.
CAN SPACE PROLONG YOUR LIFE?, Space World, v. 2, no. 4, Mar 62, pp. 56-58.

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It is possible that out of space exploration may come medical marvels which will reduce disease on earth, provide startling new cures, save doomed patients, reveal a new line of wonder drugs, and even prolong human life. It is suggested that zero-g weightlessness and certain radiations may be beneficial in the treatment of specific diseases, that future hospitals will be found in orbit, and that surgeons may operate under 100 per cent germ-free conditions in space.

262. Parin, V. V.
SOVIET EXPERIMENTS AIMED AT INVESTIGATING THE INFLUENCE OF THE SPACE FLIGHT FACTORS ON THE ORGANISM OF ANIMALS AND MAN, by V. V. Parin and O. G. Gazenko, Paper presented at the 3rd International Space Science Symposium and Fifth COSPAR Plenary Meeting, 30 Apr - 9 May 62, Washington, D. C., NASA N62-15217, 24 pp., 10 refs.

Results are given of biological experiments on space ship-satellites II, III, IY and Y and of scientific investigations made during Gagarin and Titov's flights aboard space ships Vostok I and Vostok II. It is emphasized that physiological reactions to the action of the flight stress-factors are not of pathological character. In the period of afteraction no changes in health conditions of either cosmonauts or animals were observed. At the same time some peculiarities which were revealed while analyzing physiological reactions and a number of biological indices require further investigations. The most important tasks are to study the influence of protracted weightlessness, the biological action of space radiation, the action of overloads after stay under zero-gravity and also to analyze the influence on the organism of the whole combination of spaceflight factors, including emotional strain.

263. Payne, F. A.
WORK AND LIVING SPACE REQUIREMENTS FOR MANNED SPACE STATIONS, pp. 100-104, in; Proceedings of the Manned Space Stations Symposium, Institute Aeronautical Sciences, New York, N. Y. 1960, 322 pp.

The basic knowledge required to design the work and living accomodations for space stations is presently available. Details of diet, atmosphere control, etc., may differ somewhat from information used currently for submarines and other similar closed communities, but verification of the estimated limits will derive from current research programs, such as the X-15, Mercury, and Dyna Soar. It is believed that the established principles of architecture and engineering as applied to similar surface applications has a chance of producing operationally satisfactory manned space stations.

264. Peterson, N. V.
AMERICAN ASTRONAUTICAL SOCIETY, Proc. Western Regional Meeting, 18-19 Aug 58, Palo Alto, Calif., Ed. by N. V. Peterson and H. Jacobs, AAS, New York, 1958.

Contents include:
Ward, J. E., "Considerations of Weightlessness," Special lecture, 5 pp., 6 refs.
Hoover, G. W., "Man's Operational Environment in Space," Paper no. 4, 12 pp., 13 figs.
Kornhauser, M., "Impact Protection for the Human Structure," Paper no. 38, 9 pp., 8 figs., 8 refs.

265. Petrovich, G. V.
SOVIET COSMONAUTS IN NEAR-SPACE (SOVETSKIE KISMONAVTY V BLIZHNEM KOSMOSE), Vestnik Akad. Nauk S.S.S.R. (Moscow), V. 31, no. 5, May 61, pp. 13-22, (in Russian), Also as; U. S. Joint Publ. Research Serv., Washington, D. C., Trans. no. 8897 (CSO:66-D), 19 Sep 61.

The Soviet space program is reviewed within the framework of the communist ideology. It culminated with Yu. A. Gargarin's orbiting flight and return. His performance and maintenance of physiological functions aboard the space ship showed that weightlessness is not incompatible with life and need not be a hindrance to space travel of longer duration. However, cosmic radiation constitutes a source of danger which may be avoided only by heavy shielding of the space ship or a quick retreat into the earth's atmosphere at the first sign of a solar flare. A tabular summary of the Soviet space achievements is included.

266. Picatinny Arsenal, Feltman Research and Engineering Labs., Dover, N. J.
ROCKET TECHNOLOGY AND SPACE RESEARCH, Translation no. PA-61, Nov 59, AD 228 967, 106 pp., illus., Trans. from; Raketentech. u. Raumfahrtforsch., v. 3, no. 2, Apr-Jun 59.

Contents include:
Observations on the physiology of the senses during the transition from accelerations to weightlessness.

267. Piollet, L.
THE EARTH-MOON TRIP - WILL IT ONE DAY BE A PLEASURE TRIP? (LE VOYAGE TERRE LUNE - SERA-T-IL UN JOUR UN VOYAGE D'AGREMENT?), L'air, May 60, pp. 16-18, (in French).

Discussion of the environmental conditions against which an astronaut will have to be protected. These are (1) the accelerations of launching and landing, (2) extreme temperature variations, (3) the noise and vibration of the rocket, (4) the state of weightlessness, (5) ionizing and nonionizing radiation, and (6) meteoritic impact. It is suggested that when these problems have been solved, man will have a 98% chance of surviving a journey in space.

268. Pittsburg, Univ., Dept. of Psychology, Pittsburg, Pa.
SUPPLEMENTAL BIBLIOGRAPHY ON SPACE MEDICINE, by
A. W. Bendig, 1958, 6 pp.

This bibliography contains references, particularly in the area of behavioral sciences, that were omitted from the most recent and complete bibliography of articles on space medicine: C. Roos, Bibliography of Space Medicine, (see reference 280, this bibliography).

269. Pokrovskii, A. V.
VITAL ACTIVITY OF ANIMALS DURING ROCKET FLIGHTS INTO THE UPPER ATMOSPHERE, Etudes Sovietiques (French), Jan 57, Also in;
BEHIND THE SPUTNIK, Ed. by F. J. Krieger,
Public Affairs Press, Washington, D. C., 1958.

270. Public Health Service, Washington, D. C.
BIBLIOGRAPHY OF SPACE MEDICINE, Publication no. 617
(Bibliography series 21), 1958, 49 pp.

Contents include references on acceleration, deceleration, partial and zero gravity.

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271. Quinnel, R. K.
THE HUMAN COMPONENT IN EXTRATERRESTRIAL FLIGHT, Canadian Service Med. J., v. 13, no. 4, Apr 57, pp. 245-258.

R

272. RAND Corporation, Santa Monica, Calif.
AN ANNOTATED BIBLIOGRAPHY OF RAND SPACE FLIGHT PUBLICATIONS,
Rev., Rept. no. RM-21131, Mar 59, 53 pp., 200 refs.

This annotated bibliography is a list of RAND reports on astronautics and space exploration which are currently available to military, industrial and commercial organizations with "need-to-know." Also a list of libraries where the publications may be found is included.

273. RAND Corporation, Santa Monica, Calif.
DESIGN CRITERIA FOR ROTATING SPACE VEHICLES, by S. H. Dole,
Contr. AF 49(638)-700, Rept. no. RM-2668, 18 Oct 60,
19 pp., 2 figs., 8 refs.

Several undesirable physiological side effects can arise from rotating a manned space vehicle in order to provide a

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simulated gravity field. The phenomena that may produce these side effects are herein analyzed to determine in each case the design restrictions that should be accepted in order to avoid adverse conditions. Based on this set of restrictions, a design envelope of acceptable combinations of rotation rate and radius for manned space vehicles is presented.

274. RAND Corporation, Santa Monica, Calif.
INTERNAL ENVIRONMENT OF MANNED SPACE VEHICLES, by S. H. Dole, Rept. no. P-1309, 24 Feb 58, 23 pp., 9 figs., tbl., 31 refs.

The primary elements of the environment within a manned space vehicle are summarized and their effects on the human occupant are discussed. These elements include the composition and pressure of the atmosphere, gravitational forces, temperature, and radiation.

275. Randt, C. T.
IMPACT OF SPACE EXPLORATION ON BIOLOGY AND MEDICINE, J. Am. Med. Assoc., v. 172, no. 7, 13 Feb 60, pp. 663-665.

The interest in space exploration has stimulated biologic and medical research on the tolerance and adaptability of the human organism to the stresses of acceleration, vibration, temperature, weightlessness, and isolation. It is expected that study of animals and man in actual or simulated space environments will also contribute to understanding of basic processes of consciousness, orientation, thinking, emotion, and motor coordination. The complexity and inter-dependence of problems anticipated in manned space flight call for an integrated approach by both the physical and biologic sciences.

276. Reynolds, S. R. M.
SENSORY DEPRIVATION, WEIGHTLESSNESS AND ANTI-GRAVITY MECHANISMS - THE PROBLEM OF FETAL ADAPTATION TO A FLOATING EXISTENCE, Aerospace Med., v. 32, no. 11, Nov 61, pp. 1061-1067, 16 refs.

Survey of the results of various experimental investigations of the physiology of fetal lambs, with particular attention to studies of the sympathetic and parasympathetic nervous systems. The effects of carotid artery occlusion, vagotomy, and hypoxia are discussed.

277. ROCKET SENDS MAMMALS UP 200,000 FEET, J. Am. Med. Assoc., v. 150, no. 9, 1 Nov 52, p. 948.

Monkeys and mice fired in a rocket to an altitude of about 200,000 feet returned unharmed to the ground. They withstood an initial acceleration of about 15 g lasting less than one second and a subsequent acceleration of 3-4 g, lasting 45 seconds. One mouse, placed in an empty container,

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appeared to have lost its sense of direction and orientation while floating in a gravityfree state. Another mouse, however, whose drum was provided with a shelf, was able to cling to it and command its body at will. The application to men of the findings from these animal experiments should be made with caution. Reports on pilot performance under subgravity conditions have indicated no adverse effects on the subjects' sense of orientation.

278. Rocketdyne Corp., Canoga Park, Calif.
PROPULSION REQUIREMENTS FOR SPACE MISSIONS. VOLUME III (U), Contr. NAS 5-916, Rept. no. R-3208, 13 Dec 61, AD 327 112, 1 v., tbls., 159 refs. (Confidential report).

279. Roman, J. A.
SCHOOL OF AEROSPACE MEDICINE PHYSIOLOGICAL STUDIES IN HIGH PERFORMANCE AIRCRAFT, by J. A. Roman, R. W. Ware, R. M. Adams, B. H. Warren and A. R. Kahn, Paper presented at the 1961 Meeting of the Aerospace Medical Assoc., 27 Apr 61, Chicago, Ill., Also in; Aerospace Med., v. 33, no. 4, Apr 62, pp. 412-419, 5 figs., 8 refs.

Survey of various studies made at the School of Aerospace Medicine, in which NF-100F aircraft are used for gathering physiological information in the following areas: (1) quantitative studies of physiological response of humans and animals to zero-gravity states of short duration (50 sec.); (2) development and testing of automatic physiological instrumentation for use in space vehicles; (3) development of monitoring and telemetering techniques for physiological information, and development of data reduction techniques for such information; (4) determination of physiological norms for human subjects in-flight under conditions of heightened alertness; and (5) screening of physiological parameters for suitability as indices of physiological functioning under in-flight conditions.

280. Roos, C. A.
BIBLIOGRAPHY OF SPACE MEDICINE, U. S. Armed Forces Med. J., v. 10, no. 2, Feb 59, pp. 172-217, 446 refs., Also as; National Library of Medicine, Washington, D. C., Public Health Service Publ. no. 617, 1958.

This compilation of 446 references covers aspects of space medicine such as sealed cabin problems, acceleration and deceleration, fractional and zero gravity, cosmic radiation, nutrition in space flight, survival problems, psychological and social problems, ground crew problems, and extraterrestrial aspects. Entries are arranged chronologically starting with 1958 and going back as far as 1928.

281. Schubert, G.
PHYSIOLOGY OF THE HUMAN IN FLIGHT (PHYSIOLOGIE DES MENSCHEN IN FLUGZEUZ), Springer, Berlin, 1935.

282. Schueller, O.
"Space Simulators" pp. 46-49, 16 figs., 4 refs., in;
VISTAS IN ASTRONAUTICS, Volume II, Ed. by M. Alperian and H. F. Gregory, Pergamon Press, New York, 1959, 318 pp.

A preliminary analysis and study has been made by the Aero Medical Laboratory, Wright Air Development Center of the theoretical and practical possibilities of reproduction or simulation of space flight conditions on the ground. The results and conclusions of this study are the content of this report.

283. Schwichtenberg, A. H.
MEDICAL ASPECTS OF SPACE FLIGHT, Ann. Rev. Med., v. 12, 1961, pp. 299-322.

A brief outline is given of space exploration information made possible by great advances in the physical sciences, mathematics, engineering, technology, and the life sciences. Lack of communication among highly specialized physical scientist, engineers, and physicians is largely responsible for the unusually slow adaptation of many of theses advances to medical research, instrumentation, and practice. Aerospace medicine requires a broad, multidisciplinary approach to the study of external stresses (both within the atmospheric envelope of the earth and in the environmental space beyond) that are imposed upon the human organism by circumstances of flight. Attention is given to the following stresses involved in space flight and their medical implications: acceleration, heat, vibration, radiation, decompression, hypoxia, weightlessness, noise and illumination, as well as those concerned more directly with the operation of the space craft itself, such as the cabin environment and atmospheres. The selection of astronauts, function of man in space, and man-machine relationships are also discussed.

284. Schwichtenberg, A. H.
SPACE MEDICINE AND ASTRONAUT SELECTION, Minnesota Med., v. 43, no. 12, Dec 60, pp. 797-812, 14 figs., 12 refs.

The interdependence of the fields of medicine, design engineering, and human engineering in the support of manned space flight is demonstrated in a discussion of the external stresses and hazards of space flight, including acceleration, heat, vibration, meteorites, hypoxia, decompression, radiation,

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weightlessness, noise, glare, and problems of the cabin environment and atmosphere. The various physical tests developed on the basis of the knowledge and experience gained from aviation medicine for the selection of astronauts are described. It is suggested that the research techniques employed in the space program, such as the data-processing technique for the handling of information on applicants for the astronaut program, may be usefully applied to general medical practice.

285. Sells, S. B.
HUMAN FACTORS IN JET AND SPACE TRAVEL, Ed. by S. B. Sells and C. A. Berry, New York, Ronald Press, 1961, 386 pp.

Contents include:

Graybiel, A., "Medical Aspects of Jet and Space Travel," pp. 3-23, tbl., 44 refs.

Hale, H. B., "Natural Environment and the Environment of Flight," pp. 24-4-, fig., 3 tbls., 2 refs.

Wilbanks, W. A., "Basic Aspects of Skilled Performance," pp. 61-77, fig., tbl., 9 refs.

Matheny, W. G., "Human Operator Performance Under Non-normal Environmental Operating Conditions," pp. 78-111, 8 figs., 35 refs.

Sells, S. B., "Group Behavior Problems in Flight," pp. 112-133, 41 refs.

Sells, S. B. and C. A Berry, "Human Requirements for Space Travel," pp. 166-186, 12 refs.

Clamann, H. G., "The Engineered Environment of the Space Vehicle," pp. 330-344, 2 figs., tbl.

Mayo, A. M., "Operational Aspects of Space Flgith," pp. 345-363, 12 figs., 23 refs.

Webb, H. B., "Speculations on Space and Human Destiny," pp 364-367.

286. Semotán, J.
THE IMPORTANCE OF MENTAL HYGIENE IN ASTRONAUTICS (VÝZNAM DUSEVNÍ HYGIENY V ASTRONAUTICE), Cekoslov. Psychiat. (Prague), v. 57, no. 1, Jan 61, pp. 61-69, (in Czechoslovakian with English summary).

Attention is called to the most important somatogenic as well as psychogen noxious factors in the microclimate of space ships, and to the influence of these factors on the higher nervous activity. Among the most outstanding specific one, influencing mental functions, are weightlessness, forces of gravity and subgravity, noise, ultrasound and infrasound, vibrations, isolation complicated by sensory and motor deprivation, etc. Some mental disorders endangering the crew while on space mission are analyzed in some detail. Psychogenic approaches to the selection of spacemen or members of space crews are specified and advocated. Possibilities and means of

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preservation and development of mental health, and prevention of its disturbances in spacemen and among space crews form part of the complex task of mental hygiene. Research trends in psychogenic problems of space flight are outlined.

287. Schock, G. J. D.
A STUDY OF ANIMAL REFLEXES DURING EXPOSURE TO SUBGRAVITY AND WEIGHTLESSNESS, Aerospace Med., v. 32, no. 4, Apr 61, pp. 336-340, 7 refs., (see reference no. 22 for abstract).

288. Schock, G. J. D.
A TECHNIQUE FOR INSTRUMENTING SUBGRAVITY FLIGHTS, by G. J. D Schock and D. G. Simons, J. Aviation Med., v. 28, no. 6, Dec 57, pp. 576-582, 7 figs., 4 refs., (see reference no. 23 for abstract).

289. Shurley, J. T.
PROFOUND EXPERIMENTAL SENSORY ISOLATION, Am. J. Psychiat., v. 117, no. 6, Dec 60, pp. 539-545, 3 figs., 12 refs.

Sensory deprivation experiments carried out in a specially constructed laboratory at Oklahoma City Veterans Administration Hospital are described. Light, sound, vibration, odor, and taste inputs were highly restricted. Simulated weightlessness and a uniform tactile field were achieved by placing the subject in a large tank fitted with water slowly flowing at a constant temperature. Automatic controls and continuous tape recorders completed the system. The subjects were pre-selected volunteers on the basis of capacity for self-observation, memory, and ability to communicate freely. In each case several trial runs preceded the full-length experiment. A chronological report is presented based on tape recordings by a subject in isolation for $4\frac{1}{2}$ hours. In regard to data collection, simultaneous tape recordings were found to be less inhibited, free from distortion, and more informative as to the actual experience than retrospective reports. In contrast to other methods of sensory deprivation, a water immersion situation was not perceived as unpleasant. Post-exposure feeling states varied with the subject. Certain hypotheses concerning the function of the human mind are proposed by the author and in the discussion following the paper.

290. Sisakian, N. M.
BIOLOGY AND SPACE FLIGHT (BIOLOGIIA I KOSMICHESKIE POLETY), Priroda, no. 1, Jan 61, pp. 7-16, (in Russian).

Experiments with animal rocket flights, artificial satellites carrying biological material, and other space-physiological research conducted by Soviet scientists are described. Human resistance to gravitational stress was the highest when the forces were directed in a chest-back, back-chest, left-right, or right-left direction with the man in a semi-prone

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position. Prolonged weightlessness reduced acceleration tolerance. Studies of the biochemical effects of cosmic radiation suggest no lasting changes in the nucleic acid metabolism. In the case of the dogs, Strelka and Belka, abnormally high quantities of alpha globulin, serum mucoid, and general protein were noted a few days after their return to earth.

291. Simons, D. G.
REVIEW OF BIOLOGICAL EFFECTS OF SUBGRAVITY AND WEIGHTLESSNESS, Jet Propulsion, v. 25, no. 5, May 55, pp. 209-211, 16 refs.

Disorientation and discoordination resulting from exposure to subgravity and weightlessness depend upon the response of the sensory modalities of equilibrium, vision, and kinesthesis. These modalities are infuenced by altered stimulus-sensation responses, illusions, and sensory inconsistencies. Experimental evidence of disorientation and discoordination due to exposure to subgravity and weightlessness is cited from both animal and human experiments. It is concluded that the vestibular apparatus plays a critical role in the physiological and psychological responses to subgravity exposure. The experimental evidence available to date suggests that incapacitating disorientation may occur under specific conditions.

292. Slager, R. T.
SPACE MEDICINE, Prentice-Hall, Inc., Englewood Cliffs, N. J.

Chapters included:
"Man's Entry into Space," pp. 3-18, tbl., 27 refs.
"Weightlessness," pp. 209-240, 7 figs., tbl., 44 refs.

293. Slater, A. E.
THE PROBLEM OF WEIGHTLESSNESS, Spaceflight, v. 1, no. 3, Apr 57, pp. 109-113, 3 figs., 8 refs.

294. Slater, A. E.
"Sensory Perceptions of the Weightless Condition," pp. 219-225, (in English) in; PROBLEM AUS DER ASTRONAUTISCHEN GRUNDLAGEN-FORSCHUNG (Proceedings of the 3rd International Astronautical Congress, 1952, Stuttgart), Stuttgart, 1952.

The human organism is fully able to function adequately in the absence of three basic sensations of gravity: (1) tension in muscles used for balancing, (2) sensation of pressure against any support, and (3) weight and pressure of internal organs. The fourth basic sensation of gravity is mediated by the otolith organs, which provide information of directions, changes in direction, of gravitational pull or any other linear acceleration. Assuming there is a spontaneous basic discharge of impulses to the brain by the maculae in the weightless state in spite of the absence of any pressure of otoliths on the hair cells, the different placement of the maculae in

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respect to the otoliths in the utricles and the saccules is expected to result in contradictory messages. An alternative hypothesis based on experiences of pilots on blind flights and divers who have dived blindfolded leads to conclude that the real function of the otoliths is not transmission of information but (a) the regulation of muscles for maintenance of equilibrium, and (b) the regulation of eye movements during changes in position of the head to facilitate continuous fixation of objects.

295. Slayton, D. K.
ASTRONAUTS DISCUSS MERCURY TRAINING, by D. K. Slayton and A. B. Shepard, Aviation Week & Space Technol., v. 74, no. 25, 19 Jun 61, pp. 67, 71, 73-75, 77, 79.

The two astronauts describe their training program for Project Mercury. Training for weightlessness was carried out by aircraft maneuvers which produced zero g for 15-30 seconds. The interior of one airplane was prepared so that movement in the weightless state was carried out. In a human centrifuge at a simulated altitude of 27,000 feet the astronauts developed various techniques for adjusting to high accelerations and high altitudes. Training for working under heat loads was carried out in temperatures up to 250°.F., while exposure to high concentrations of CO_2 was done in a special chamber. Survival training on water included exercises in distilling water and learning methods of sun protection. During the latter stages of training, there was an intensive period of monitoring of the astronauts' health to insure their well-being. The overall psychological effect of the training period was to instill confidence in the astronauts.

296. Snyder, R. G.
MANNED SPACE FLIGHT VEHICLES AND THE PHYSICAL ANTHROPOLOGIST, Am. J. Phys. Anthropol., v. 19, no. 2, June 61, pp. 185-193, 55 refs.

Anthropometrics and biomechanics have already helped to elucidate problems in aeronautical science. Future problems of interest include hypersonic escape, space capsule environments, seating and restraint, weightlessness, human tolerance to various physical forces, criteria of physique, recycling of wastes in nutrients, radiation effects and a vast array of other biological and cultured relationships. The author briefly outlines the role of physical anthropology in some of these areas. Regarding the problem of restraint, a complete outline of requirements for a minimum restraint system is given. Feeding, walking, and medical problems are discussed in conjunction with the weightless condition. In conclusion it appears that physical anthropology having the most comprehensive range of knowledge of man, will contribute much to future research in aerospace medicine.

297. SOVIET EXPERIMENTS ON EFFECTS OF WEIGHTLESSNESS ON HUMANS, Est. Hirlap (Hungarian), 8 Nov 57.

298. Space Technology Laboratories, Inc , Redondo Beach, Calif. A PRELIMINARY EXPERIMENT WITH RECOVERABLE BIOLOGICAL PAYLOADS IN BALLISTIC ROCKETS. PROJECT MIA, by F. L. van der Wal and W. D. Young, Rept. no. GM-TR-0165-00498, STL reprint no. 298, Sep 58, 38 pp., 20 figs.

Mice carried in the nose cone of long-range ballistic missiles have successfully survivied re-entry into the atmosphere. In most aspects, the environmental conditions experienced by these subjects exceeded in severity those which will be imposed on satellite passengers. Although no new technique were used, this program represents a significant step forward from the early pioneering flights of mice and monkeys in relatively low-performance sounding rockets. The relative success of these experiments permits a considerable degree of confidence in the ultimate successful recovery of biological payloads from future satellite vehicles.

The project, known as Project MIA (Mouse-In-Able), was planned as a noninterference experiment in conjunction with the Project Able re-entry test program. In each of the three Able flights, one mouse was carried in the nose cone. Although none of the nose cone was recovered, telemetered physiological records were obtained on the second and third Able flights.

Preparation for the flights included planning of the program, designing and fabricating of the MIA package, developing of instrumentation (including the technique of sensor implantation in the animal and signal amplification), testing of the assemble unit (including the mouse) for duration and ability to withstand environmental conditions anticipated in the flight profile, and providing equipment and instruction to personnel aboard the recovery ships to assure obtaining maximum experimental data. This prepatory work was accomplished and the first flight occurred within one month after official authorization.

This report includes a detailed description of the physical system, the preliminary tests and flight preparations, the instrumentation used in flight, and the resulting signal pattern. The special problems associated with the use of living payloads in space-flight vehicles are also discussed.

299. Space Technology Laboratories, Inc., Redondo Beach, Calif. THE WORLD'S FIRST TANDEM FLIGHT IN SPACE (BASIC RESULTS) [PERVYI V MIRE GRUPPOVOI POLET V KISMICHESKOE PROSTRANSTVO (OSNOVNYE ITOGI)] , Trans. by Z. Jakubski, Trans. no. 70, Nov 62, 24 pp., 5 tbls., from; Pravda, no. 295(16151), 22 Oct 62, pp. 1-3.

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A presentation of the Russian VOSTOK 3 and 4 space flights and a review of the experiments which took place during the flight. During the weightlessness experiments, A. G. Nikolaev floated in the capsule for a total of 3.5 hours (in 4 "sessions") and P. R. Popovich for about 3 hours (in 3 "sessions"). During these periods they felt fine, conducted observations, and communicated with the ground by means of microphones. A number of experiments within the capsules were conducted. P. R. Popvich observed air bubbles in a hermetically sealed flask two-thirds filled with water. While the flask was at a state of rest, the air formed one big bubble in the center of the water. After shaking, the air bubble broke into a number of small bubbles which eventually gathered again as a single bubble. Drops of water sprinkled inside the capsule moved towards the walls and eventually settled there.

300. Stallings, H. D., Jr.
PRODUCING THE WEIGHTLESS STATE, by H. D. Stallings, Jr. and S. J. Gerathewohl, Flying, v. 61, Nov 57, pp. 33-34, 80-82, illus.

Report on SAM studies of weightlessness conducted in T-33 and F-94C aircraft flying the "Keplerian Trajectory".

301. Stallings, H. D.
THE WEIGHTLESS MAN, by H. D. Stallings, Space J., v. 2, no. 2, Dec 59, pp. 13-15, 41-45, 4 figs.

A general discussion on the effects of weightlessness which covers some of the earlier parabolic flights in a T-33.

302. Strughold, H.
MECHANORECEPTORS, GRAVIRECEPTORS, J. Astronautics, v. 4, Winter 57, pp. 61-63, 16 refs., Also in; Air Force School of Aviation Medicine, Randolph AFB, Tex., Epitome of Space Medicine, Item 39.

Attention is given to the sensing devices called mechanoreceptors or gravireceptors, located in the skin, in the skeletal muscles and in the connective tissue, which aid man's perception of the position and movement of his limbs and of the whole body. The anatomy of these mechanoreceptors, their physiological function under normal gravitational and zero-gravity conditions are discussed.

303. Strughold, H.
"The Medical Aspects of Manned Space Flight," chapter 28, 22 pp., 4 figs., 65 refs., in; SPACE TECHNOLOGY, Ed. by H. Seifert, Wiley and Sons, Inc., New York, 1959, 33 chapters.

304. Strughold, H.
MEDICAL PROBLEMS INVOLVED IN ORBITAL SPACE FLIGHT,
Jet Propulsion, v. 26, no. 9, Sep 56, pp. 745-756, fig., 36 refs.

After analyzing the various kinds of space operations that might be expected in the near or remote future (space equivalent flight, circumplanetary space flight, and interplanetary space travel), the second phase -- circumplanetary space flight or orbital space flight -- is chosen as a platform for the discussion of some of the most important medical problems involved in space operations. First, the state of weightlessness is discussed with regard to its effect upon the general well-being of the occupants of a satellite vehicle and in regard to it sensomotor effects. In connection herewith, the optical situation is considered with regard to the properties of the environment and the visual appearance of the light sources. Furthermore, physiological day-night cycling is discussed in an environment where there is no natural day and night. And finally some problems involved in human engineering of the space cabin concerning pressurization, supply of oxygen and removal of carbon dioxide, photosynthetic gas exchange, and the event of sudden decompression of the cabin are discussed. Some of these problems are presently under study in an experimental space cabin simulator.

305. Strughold, H.
"Sensory-Physiological Aspects of the Space Flight Situation," pp. 57-65, 2 tbls., 20 refs., in; PSYCHOPHYSIOLOGICAL ASPECTS OF SPACE FLIGHT, Ed. by B. E. Flaherty, Columbia Univ. Press, New York, 1961, 393 pp.

A review of the physiological function of the peripheral, extra-labyrinthine, mechanical sense organs (skin pressure, muscle tension, and posture sense receptors) under normal gravitational conditions is followed by a discussion of their functions during conditions of zero gravity. Tests in parabolic flight maneuvers have confirmed the assumption that these predominantly proprioceptive senses are not affected by zero gravity. However, experimental data on man's tolerance to weightlessness over longer periods of time are not yet available, and provision of artificial gravitation (by rotation or slight continual linear acceleration) may become a necessity.

306. Stone, R. W., Jr.
THE EFFECTS OF ANGULAR MOTION OF ROTATING SPACE VEHICLES ON THE ABILITY OF AN ASTRONAUT TO PERFORM SIMPLE TASKS, by R. W. Stone, Jr. and W. Letko, Paper presented at the Annual Meeting of the Inst. of Environmental Sciences, 10-13 Apr 62, Chicago, Ill., NASA N62-12166, 1962, 25 pp., 8 refs. (OTS: $2.60).

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Use of angular motion to simulate effects of gravity in weightless space is a possible solution to the prevention of deterioration of muscle tone, muscle atrophication, and debilitation of the cardiovascular system that man may face when exposed to long periods of weightlessness. Tests are conducted to determine the maximum rotational rate that will not induce motion sickness by head and body movement when rotating a space vehicle 24 feet in diameter. Test results showed that stimulation of the vestibular organs of the inner ear can be caused by rotational rates beyond 10 r.p.m. The cross-coupled dynamics involved when moving the head or body in a rotating vehicle may cause the vestibular stimulation. Also there was a decrease in effectiveness in task performance as the vehicle rate of rotation increased. Thirteen of 29 subjects tested failed to complete the entire experiment. Also, the subjects that completed the tests experienced a reduction in efficiency at the higher rotational rates (beyond 10 r.p.m.). All subjects experienced malaise and nystagmus, both being particularly bothersome beyond 10 r.p.m. The results further suggest the need for experiments wherein the head motion is controlled to remain below certain of the tolerance boundaries suggested, so as to determine if efficiency can be maintained below the tolerable limits.

307. Stutman, L. J.
EFFECTS OF ZERO GRAVITY UPON THE CARDIOVASCULAR SYSTEM, by L. J. Stutman and R. Olson, Armed Forces Med. J., v. 11, no. 10, Oct 62, pp. 1162-1168, 4 figs., tbl., 4 refs.

Some preliminary investigations of the effects of zero gravity upon the cardiovascular system reveal a pronounced slowing of heart rate, a slight diminution of blood pressure, and a tendency to peripheral pooling subsequent to the positive G load. Position in the zero G field does not seem to affect the cardiovascular system. Hypotheses are proposed for the potential circulatory difficulties that will hamper a person's return to earth.

308. System Development Corp., Santa Monica, Calif.
THE PSYCHOLOGICAL AND SOCIAL PROBLEMS OF MAN IN SPACE: A LITERATURE SURVEY, by B. D. Goodman, Rept. no. FN-5220, 2 Mar 61, AD 252 434, 67 pp., 190 refs.

This bibliography brings together the reports, books, and periodical articles published through January 1961 in the specific area of behavioral science related to space flight, or as it is sometimes call space psychology. This area includes social and sensory isolation, psychological assessment and training, fatigue, confinement, performance under stress, work schedules, motivation, weightlessness, disorientation, emotional stability and the day-night cycle.

308. THEY'RE OFF! THE MONKEYS AND THE MICE: PHYSIOLOGICAL RESEARCH ON ANIMALS LEADING TO HUMAN SPACE-FLIGHT, Western Aviation, v. 32, no. 11, 1952, p. 12.

Two monkeys and two mice have survived a ride to an altitude of 200,000 feet in Aerobee and V-2 type rockets fired from Holloman Air Force Base at Alamogordo, New Mexico. The experiment was carried out by the U. S. Air Force Air Research and Development Command. The monkeys had been anesthetized to prevent them from interfering with the recording instruments. The mice were placed in two separate drums, one smooth on the inside, the other provided with a small shelf. An initial acceleration of 15 g for less than one second was followed by 3 to 4 g for about 45 seconds. At the peak of the trajectory the animals were weightless. Films taken during the flight showed the "floating" mouse in a state of complete disorientation and unable to co-ordinate its movements. The mouse in the drum provided with a shelf was able to hold on to it and command its body at will. -- A statement by Major Charles Yaeger on his reactions during near-zero-conditions (while following a ballistic trajectory) confirmed the fact that proper performance of the pilot is not impaired under such conditions.

309. Thompson, A. B.
PHYSIOLOGICAL CONSIDERATION IN DESIGNING FOR ARTIFICIAL GRAVITY IN MANNED ROTATING SPACE SYSTEMS, Paper read by title at 33rd annual meeting of the Aerospace Medical Assoc., 9-12 Apr 62, Atlantic City, Abstracted in; Aerospace Med., v. 33, no. 3, Mar 62, p. 372.

If future manned orbital flights prove long term weightlessness to be an unacceptable physiological stress, one practical method of achieving simulated gravity will be to rotate the vehicle such that the resulting centrifugal force provides an apparent gravity vector. A few significant drawbacks to this technique will impose design restrictions on the vehicle if they are to be made physiologically acceptable to the crew. These parameters are discussed and physiological design limits defined. An acceptable design envelope is presented with limits as to radius of rotation, maximum angular velocity, minimum and maximum G, and limit coreolis accelerations in per cent of apparent gravity and rate of crew movement.

310. Thompson, L. N.
MAN WITHOUT GRAVITY: THE PHYSIOLOGICAL AND PSYCHOLOGICAL PROBLEMS OF SPACE FLIGHT, Flight (London), v. 61, 14 Mar 52, pp. 298-300.

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The principal physiological functions of the human body, such as respiration, circulation, and digestion, are primarily muscular in action and therefore independent of gravitational pull. The action of the labyrinthic fluid in the inner ear is determined by mass inertia rather than by weight. The otolith organs on the other hand require a gravitational field for their normal operation. However, it is not known what nervous impulses would be transmitted by the otolithic organs under true zero g conditions; experimental evidence allows the assumption that vision and somatic sense organs would partly compensate for disturbances in balancing mechanism of the inner ear. -- The author summarizes other problems that will arise in actual space flight, such as the need for atmospheric circulation because of lack of convection currents, prevention of blackouts during high take-off accelerations, protection from radiation, the possibility of infection by alien viruses and germs encountered on other planets, and the need of proper preparation against psychological crises on extended flights.

311. Titov, G.
HALF A MILLION MILES THROUGH SPACE, Atlantic Adv., v. 52, no. 12, 1961.

312. Tobias, C. A.
OUR VIEW OF SPACE BIOLOGY WIDENS, by C. A. Tobias and J. V. Slater, Astronautics, v. 7, no. 1, Jan 62, pp. 20-22, 47-52, 7 figs.

Putting a man safely into space requires knowledge concerning his ability to withstand the stresses resulting from acceleration-deceleration, weightlessness, temperature changes, vibrations, tumbling, artificial gas environments, and radiations. The importance of biological research in the space program is emphasized. For example, in radiobiology, two aspects under study are the neurological effects of radiation, and its developmental physicist. Underlying physical causes for the effects of weightlessness probably involve alterations in convection patterns of liquids and gases. These appear to change the mode of mixing and the phase changes and might also result in reduced cell division. Many examples are given of phenomena both observed and considered for future research.

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313. Virginia Univ., Charlottesville
HUMAN FACTORS AT EXTREME ALTITUDES: SYNOPSIS AND BIBLIOGRAPHY, by F. W. Baughart and E. G. Pattishell, Contr. AF 18(600)-1792, Rept. no. HQARDC TR 60-7, Mar 60, AD 242 348, 115 pp., 1211 refs.

Continued

Review of the literature for the period up to 1959 on the following subjects: ecology, behavior and performance, acceleration and deceleration, weightlessness, radiation, and instrumentation.

314. von Beckh, H J.
EXPERIMENTS WITH ANIMALS AND HUMAN SUBJECTS UNDER SUB- AND ZERO-GRAVITY CONDITIONS DURING THE DIVE AND PARABOLIC FLIGHT, J Aviation Med., v. 25, no. 3, Jun 54, pp. 235-241, 5 figs., 16 refs.

Behavior study of certain species of chelonia (turtles), which are found on parts of the South American continent, under sub- and zero-gravity conditions.

315. von Beckh, H. J.
GRAVITY CHANGES IN AIRCRAFT AND SHIPS, Brit. Interplanet. Soc. J., v. 15, no 2, Mar-Apr 56, pp. 73-81, 4 figs., 24 refs.

316. von Beckh, H. J.
HUMAN REACTIONS DURING FLIGHT TO ACCELERATION PRECEDED BY OR FOLLOWED BY WEIGHTLESSNESS, Aerospace Med., v. 30, no. 6, Jun 59, pp. 391-409, 11 figs., 24 refs.

Alternation of weightlessness and acceleration results in a decrease of acceleration tolerance and of the efficiency of physiologic recovery mechanisms. This indicates that acceleration thresholds of reversible, and irreversible injury will be lower in space flight conditions than in the one G field of man's earthly environment. Defects of circulation, muscular effectiveness, vision, and of conscious judgment will occur at lower acceleration values and will probably continue for longer times than they do under present normal flight conditions In an astronautical venture depending upon the skill of a human pilot, a blackout, lapse of judgment or even the slightest reduction in efficiency at a crucial time, could undoubtedly cause the failure of the mission.

The implications for planning or manned space flight are, first, that thrust values and reentry profiles must take the lower acceleration tolerance into consideration and, second, that adequate G protection must be designed for the pilot to prevent dangerous effects of high acceleration.

317 von Beckh, H. J.
"The Incidence of Motion Sickness During Exposures to the Weightless State: in; SPACE MEDICAL SYMPOSIUM, Astronautik (Stockholm), v. 2, no. 4, 1961, pp. 217-224.

The incidence of motion sickness is approximately 30 per cent in weightlessness experiments using fighter aircraft, where the subject is restrained. In cargo aircraft where the

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subject is unrestrained and able to float within the cabin, the incidence is considerably higher. Consideration is given to the fact that in all parabolic-flight experiments the subjects were exposed to accelerations of 2-3 g (even up to 6.5 g) before and after the weightless parabola. It is difficult to distinguish effects due to acceleration from those due to weightlessness per se. Vagal symptoms at the time of burnout and re-entry decrease the operator's capability to perform. However, should it be true that weightlessness per se is able to produce motion sickness, then the operator would be liable to suffer vagal symptoms of long duration, which could incapacitate him to a high degree. The applicability of the Weber-Fechner law in this respect is discussed.

318. von Beckh, H. J.
SPACE FLIGHT HAZARDS CAUSED BY WEIGHTLESSNESS, Paper presented at the 1959 Meeting of the Aero Medical Assoc., 27-29 Apr 59, Los Angeles, Calif., Abstracted in; Aerospace Med., v. 30, no. 3, Mar 59, p. 208.

The lack of neuromuscular coordination and optical illusions, as they might possibly affect the efficiency of the human operator of a space vehicle, are discussed. However, it should be expected that more difficulties would arise from the alternation of high G loads and weightlessness which increases discomfort and lowers human tolerance to G loads.

319. von Beckh, H. J.
A SUMMARY OF MOTION SICKNESS EXPERIENCES IN WEIGHTLESS FLIGHTS CONDUCTED BY THE AEROMEDICAL FIELD LABORATORY, Paper presented at the Symposium on Motion Sickness in Weightlessness Research Mar 60, Wright-Patterson AFB, Ohio.

320. von Beckh, H. J.
WEIGHTLESSNESS AND SPACE FLIGHT, Astronautics, v. 4, no. 2, Feb 59, pp. 26-27, 84, 86, 3 figs.

Deterioration of neuromuscular co-ordination and disorientation are considered to be originated by the weightless state per se. However, more complex problems arise during extended space flights, as well as during alternate acceleration and weightlessness, such as occurs during the ascent and re-entry of space vehicles. Results of experiments in jet aircraft are cited to show that the weightless state aggravates other physiological conditions, which, in combination, pose serious problems to man in space flight. Subjects reported experiences of increased susceptibility to or severity of acceleration effects when they entered positive G states immediately after experiencing weightlessness. Subjects who normally blacked out at 5 G could tolerate only 3.5 to 4 G in the experiments. In the opposite case, when acceleration preceded weightlessness, physiological recovery mechanisms seemed

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disturbed. Blackout lasted longer, and more severe discomfort and chest pains were reported. Cinematographic observations, registrations of heart rate, electrocardiograms, and galvanic skin responses corroborated the subjective reports. It is suggested that extended weightlessness may lead to lessened muscle tone and strength, as well as to inconveniences to the cardiovascular system. The heart, having transported the blood without the force of gravity during the weightless state, would need a certain time for adaptation after re-entry into the gravity field of the earth or of another planet.

321. von Diringshofen, H.
AEROMEDICAL PROBLEMS OF WEIGHTLESSNESS (FLUGMEDIZINISCHE PROBLEME DER GEWICHTSLOSIGKEIT), Munch. Med. Wchnschr., v. 101, no. 32, 1959, pp. 1326-1328, 1345-1349, (in German).

The transition from air flight to space flight makes weightlessness one of the most important problems of aerospace medicine. The condition of weightlessness has been already experienced up to a duration of 50 seconds in parabolic flight. The sensations observed therein of stall, fall, and vertigo emanate from the organ of equilibrium. The confusion of the equilibrium center in the brain may also affect the vegetative nervous system and provoke nausea. The type and strength of these disturbances is determined by the following factors: (1) individual sensitivity, which can be reduced by training, (2) abruptness of transition, from gravity to weightlessness, and (3) irregularities in this transition. In a state of free weightless suspense, body rotations with additional tilting of the head may cause Coriolis accelerations in the labyrinth, thus bringing about strong nausea. In the course of protracted weightlessness, one must expect increasing phychical and physical enervation with subsequent reduced resistance to acceleration. Such conditions can be prevented by previous rigorous aero-gymnastics as well as by aerodynamical parabolic flights. It seems reasonable that carefully selected fliers may sustain not only short periods of weightlessness but also a prolonged weightless condition in space flight without serious disturbances, provided they are well trained, remain strapped in their seats, and have become adjusted to the extraordinary sensory perceptions of a weightless environment. To what extent weightlessness may affect blood circulation cannot yet be predicted since disturbances experienced by fliers in from 20- to 30-second parabolic flights may as well be due to the transition or irregularities in the transition to weightlessness. A partial reduction of gravity, say to 1/3 G, may even produce pleasant sensations, such as we experience when we completely relax in a warm bath tub.

322. von Diringshofen, H.
INTERNATIONAL SYMPOSIUM ON AEROSPACE MEDICINE (INTERNATIONALES SYMPOSIUM UBER LUST-UND RAUMMEDIZIN), Weltraumfahrt (Frankfurt), v. 12, no. 1, Feb 61, pp. 11-12, (in German).

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The symposium, sponsored by the Aviation Medicine Institute of the Argentine Air Force, was held 6-13 Oct 60, at the School of Medicine, University of Buenos Aires. Discussions centered on the psychological aspects of space flight, acceleration forces, and acceleration tolerance. Films of rocket-sled studies and of weightlessness during aircraft maneuvers and during free fall in a pressure suit from a balloon gondola were shown. Discussions made clear the differences in European and American outlooks on the relative importance of psychological tests in the evaluation of space flight candidates. Attention was also given to the physiology of respiration and the effects of oxygen lack on the endocrine system, tissue damage caused by decompression, and the human engineering problems of space flight.

323. von Diringshofen, H.
"Medical Problems of Space Flight (Medizinische Probleme der Raumfahrt)", in; RAUMFAHRTFORSHUNG, Ed. by H. Gartmann, Munich, Oldenburg Press, 1952.

324. von Diringshofen, H.
SENSORY-PHYSIOLOGICAL OBSERVATIONS DURING THE TRANSITION FROM ACCELERATION TO WEIGHTLESSNESS, (SINNESPHYSIOLOGISCHE BEOBACHTUNGEN BEIM UBERGANG VON BESCHLEUNIGUNGEN ZUR GEWICHTSLOSIGKEIT), Raketentech. u. Raumfahrtforsch.(Stuttgart), v. 3, no. 2, Apr 59, pp. 33-35, (in German).

A review of three experiments is presented concerning the immediate physiologic and psychologic effects of short exposures to subgravity. 1. About 20 years ago, the author induced weightlessness by vertical dives in a Ju-87 aircraft for durations of 7-8 seconds (radial acceleration 8 G). The psychologic reactions was a pleasant one, and the sensation of "slumping," which usually introduces weightlessness episodes, was not perceived. 2. In 1954, while in Argentina, the author achieved weightlessness in parabolic flight for durations of 12-14 seconds, preceded by an acceleration of 5 G lasting 5 seconds. Transitional accelerations of 2 G preceding weightlessness lasted 2 seconds. Disagreeable sensations of "slumping" and of falling through empty space were distinctly perceived for about 5 seconds after the onset of weightlessness, leading over eventually to a sensation of floating in space. 3. In a "subgravity tower" designed by Dr. T. Lomonaco at the Aeromedical Research Institute in Rome, weightlessness was produced in a seat suspended from and catapulted upward by rubber straps fastened to the top of a 15-m.-high tower. Initial acceleration was 3 G and lasted .5 second. Three launchings were carried out consecutively, inducing weightlessness for 2, 1.3, and .8 seconds, respectively. At the point of transition from acceleration to weightlessness a very disagreeable sensation of falling is perceived. The findings of these three experiments carried out in the United States by Gerathewohl and

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others, can only be considered preliminary to weightlessness conditions in space travel. There is evidence to the effect that acclimatization takes place when weightlessness extends over longer periods. It appears that nausea and other disagreeable sensations are experienced less frequently by individuals actively engaged in navigation or in other mind-absorbing tasks than by "passive" riders. In conclusion, the author speculates on the possibility that changes in G force during the various accelerative launching stages may be particularly inducive to "space sickness."

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325. Walton, H., Jr.
A DEVICE FOR ARTIFICIAL PRODUCTION OF ALTERNATING GRAVITATIONAL FORCES, J. Aviation Med., v. 28, no. 3, Jun 57, pp. 291-294, 3 figs., tbl., 2 refs.

Report is a proposal for a device which is suitable to produce alternating gravity forces including intermittent gravity free state at ground level, over indefinitely long periods of time. Two forms of the device, named "Gravitron" for brevity, are schematically shown.

326. Ward, J. E.
BIOMEDICAL CONSIDERATION OF WEIGHTLESSNESS, Paper presented at the American Astronautics Society Meeting, 18 Aug 58, Palo Alto, Calif.

327. Ward, J. E.
PHYSIOLOGIC RESPONSE TO SUBGRAVITY. II. INITIATION OF MICTURITION, by J. E. Ward, W. R. Hawkins and H. D. Stallings, J. Aerospace Med., v. 30, no. 8, Aug 59, pp. 572-575, Also as; Air Force School of Aviation Med. Brooks AFB, Tex., Rept. no. 59-35.

This study was concerned with the elimination of liquid body wastes in the null-gravity state. Specifically, the accomplishment of urination was observed for 20 male subjects during 30 to 40 seconds of weightlessness in an F-94C Starfire jet under special flight maneuvers. A urine receptacle, fabricated from scrap oxygen hose and a weather balloon, was used since the relief tube was completely unacceptable. Thirty-seven flights were made. Implications for space flight are indicated.

328. Ward, J. E.
PHYSIOLOGICAL ASPECTS OF HYPERGRAVIC AND HYPOGRAVIC STATES: APPLICATION TO SPACE FLIGHT, J. Am. Med. Assoc., v. 172, no. 7, 13 Feb 60, pp. 665-668

Continued

The extremes in gravitational forces which will confront man in space flight range from above 40 G during deceleration to zero gravity during flight in orbit. It has been shown experimentally that the human organism tolerates up to 50 G applied at 500 G/second for less than 0.2 second. A more rapid rate of application reduces the tolerance limit. Tolerance during the powered flight phase with acceleration forces of 4 to 10 G, will be raised by proper positioning. The functional problems of the human body subjected to periods of zero gravity concern neurologic mechanisms, spatial orientation, motion sickness, cardiovascular and gastrointestinal functions, waste elimination, psychomotor performance, and diurnal rhythms. There is some indication that acclimatization to weightlessness may result in lower positive G tolerance upon re-entry. Collection of additional psychophysiologic data will be one of the more important objectives of manned space flight.

329. Ward, J. E.
PROSPECTS AND LIMITATIONS OF HUMAN FLIGHT BEYOND THE ATMOSPHERE. THE ELUSIVE SPHERE OF INTEREST, by J. E. Ward and D. G. Simons, Paper presented at the International Council of the Aeronautic Sciences, 12 Sep 58, Madrid, Spain.

330. Warren, B. H.
"Weightlessness - A Physiological Problem in Space" NASA N62-14204, pp. 115-134, 8 figs., 3 tbls., 33 refs., in; LECTURES IN AEROSPACE MEDICINE, Air Force, School of Aerospace Medicine, Aerospace Medical Div., Brooks AFB, Tex., Armed Forces Press Service, 1962, 447 pp.

Whether prolonged weightlessness will pose serious physiological problems remains a serious question in space medicine. Progress is being made by biological experimentation during short periods of weightlessness and by various types of weightlessness simulation. Since changes in hydrostatic blood pressures trigger the autonomic nervous system reflexes controlling heart rate, vasoconstriction and vasodilation, it is conjectured that these reflexes may not respond after prolonged disuse, and an abrupt acceleration might cause blood to pool in the extremities reducing the vital organ blood supply. Disorientation is another aspect of weightlessness; this involves the vestibular apparatus, vision, and other orientation sensing mechanisms. Two illusions reported during weightlessness are being studied; the oculogyral illusion and the oculogravic illusion. They are mediated by the same physiological mechanisms which are involved in seasickness and airsickness. The final answers to all the physiologic problems of weightlessness depend on attaining prolonged periods of true weightlessness.

331. Wells, R.
ALIVE IN SPACE: THE SCIENCE OF BIO-ASTRONAUTICS, Little, Brown and Co., Boston, 1961, 180 pp.

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This is an illustrated treatise on space flight dealing with the following topics: space instruments, space mechanics, space vehicle, weightlessness in space, living in space, safety in space, crewmen in space, man's mind in space, training for space, science in space, and the will to space.

332. Whillans, M. G.
BIOSCIENCES RESEARCH AND SPACE PROBLEMS, Roy. Astron. Soc. Can. (Toronto), v. 54, no. 5, Oct 60, pp. 211-215.

A brief review is presented of the following problems attendant to manned space flight: (1) disorientation and weightlessness, (2) radiations from the Van Allen belts and solar flares, (3) isolation, and (4) methods of providing food and oxygen. Remarks are included on some of the proposed solutions to these problems. Efforts to solve these problems have stimulated discussions and research into such basic areas as the origin of life, the possibility of life on other planets, the relationship of biological rhythms to the health and efficiency of the human organism, mechanisms of navigation in birds and other animals, and possibilites of traveling in space in the supercooled or hibernating state.

333. White, S.
PHYSICS AND MEDICINE OF THE UPPER ATMOSPHERE,(Proc. Sym. on the Phys. and Med. of the Upper Atmosphere, San Antonio, Tex., 6-9 Nov 51), Ed. by C. S. White and O. O. Benson, Jr., Albuquerque, Univ. New Mexico Press, 1952, 611 pp.

Contents include:

Mayo, A. M., "Basic Environmental Problems Relating Man and the Aeropause," pp. 6-22, 12 figs., 15 refs.

Strughold, H., "Basic Environmental Problems Relating Man and the Highest Regions of the Atmosphere as Seen by the Biologist," pp. 23-34, 5 figs., 32 refs.

Haber, H., "Gravity, Inertia, and Weight," pp. 123-136, 5 figs., 9 refs.

Campbell, A., "Human Orientation During Travel in the Aeropause," pp. 488-493, tbl., 13 refs.

Graybiel, A., "The Effect on Vision Produced by Stimulation of the Semicircular Canals by Angular Acceleration and Stimulation of the Otolith Organs by Linear Acceleration," pp. 494-508, 9 figs., 24 refs.

334. White, M. S.
THE AEROMEDICAL REALITIES OF SPACE TRAVEL, J. Aviation Med., v. 29, no. 10, Oct 58, pp. 707-715, 6 figs., 14 refs., Also in; Air Force, v. 41, no. 12, Dec 58, pp. 76-79.

A review of Aviation Medicine and its progress.

335. White, S. C.
"Progress in Space Medicine," pp. 231-241, in; IL CONGRESSO MONDIALE E IV EUROPEO DI MEDICINA AERONAUTICA E SPAZIALE, v. 1, Rome, 1961.

Both the X-15 and Mercury programs offer the opportunity to study men in space flight through the use of instrumentation placed upon the crewman. The biological areas considered in these programs include: acceleration, deceleration, and weightlessness; acoustic energies (sound and vibration); atmosphere, temperature and humidity; decompression; radiation; work capacity and physical fatigue; orientation; day-night cycles; hygiene, illness; and diet and waste handling. The gathering of data under both programs has required a completely new approach to biological instrumentation.

336. Whiteside, T. C. D.
THE EFFECTS OF WEIGHTLESSNESS ON SOME POSTURAL MECHANISMS, Paper presented at the 1960 Meeting of the Aerospace Medical Assoc., 9-11 May 60, Miami Beach, Fla., Abstracted in; Aerospace Med., v. 31, no. 4, Apr 60, p. 324.

The performance of an aiming task in which a subject has to point to the center of a target before him, depends on the coordination of visual information with intact proprioceptive and efferent mechanisms. When the task is carried out with the eyes closed, some verification of performance is still possible -- especially if the hand is brought back to touch the nose as in the well-known clinical test. Such an aiming test with eyes closed has been carried out while the subject was exposed to different G forces including zero-G. In addition, subgravity was simulated by water immersion which of course affected only muscle joint sense and not the utricular otoliths. When the balance of anti-gravity muscles was altered by one of these procedures, the tests showed an initial inaccuracy of aim, followed by an improvement with time and experience. The loss of orientation in an aircraft cabin which is immersed and filled with water is most probably due to this altered muscle balance, together with the absence of visual information and the reduced proprioceptive clues as to the direction of the vertical. In the flight experiments on zero G, tendon reflexes were present, but in laboratory experiments carried out by dropping subjects, it was found that the myotatic reflexes elicited by tapping the tendo achilles, disappeared shortly after the onset of zero G, reappearing about 100 m./secs. later. This was probably associated with the steplike change from one to zero G and it seems that the responsible factor was the resultant passive movement of the leg muscle together with consequent shortening of the muscle spindle. It was found that even when the subject was not dropped, a small extension of the foot about the ankle joint produced a similar disappearance of the ankle jerk for about

Continued

100 m./secs. The re-appearance of the response after this time appears to be due to the re-establishment of spindle tone by supra spinal control. It is unlikely that labyrinthine factors were responsible for the temporary loss of tendon reflex under zero G, since the time at which the reflex disappeared was not cause to vary by varying the time at which the head became weightless relatively to the leg.

337. Whiteside, T. C. D.
HAND-EYE COORDINATION IN WEIGHTLESSNESS, Aerospace Med., v. 32, no. 8, Aug 61, pp. 719-725, 5 figs., 3 tbls., 6 refs.

Experiments similiar to those of von Beckh (1954) wherein he employed his test to determine the ability of subjects to point at a target under zero G in flight, both with eyes open and with eyes closed, are repeated, but without visual information on performance, yet with a visual fixation point so that eye movement might be controlled.

338. WHY LUNAR RENDEZVOUS?, Space World, v. 3, no. 3, Sep 62, pp. 6-7, 5 figs.

A comparison of earth and Lunar rendezvous programs is presented. Secondary programs discussed include; (1) Lunar Logistics Carriers wherein one or more caches of supplies including space fuel, food, water and oxygen will be waiting at the predetermined landing spot and (2) Surveyor vehicles, which will explore the surface of the moon.

339. Winter, K.
THE FIRST STEP INTO THE UNIVERSE (DER ERSTE SCHRITT INS WETTALL), Weltraumfahrt (Frankfurt), v. 12, no. 4, Jul-Aug 61, pp. 101-103, (in German).

Data from the open Soviet literature and newspapers on Yu. Gagarin's orbital flight are compiled in a description of the historical event. According to Gagarin's own description he made observations, ate and drank, wrote notes, and was not adversely affected by weightlessness. The climatic conditions in the cabin were 1% CO_2, 15-22°C. temperature, and 30-70% humidity. Oxygen regeneration was effected through highly active chemical compounds. During the flight Gagarin wore a space suit. Education, training and background of the Soviet astronauts are similar to the American group. Preparation for flight included parabolic flights, centrifuge rides, and parachute jumps.

Y

340. Young, R. S.
"Basic Research in Astrobiology," pp. 317-327, 8 figs., in; ADVANCES IN THE ASTRONAUTICAL SCIENCES, Volume 6, Ed. by H. Jacobs and E. Burgess, The Macmillan Company, New York, 1961, 898 pp.

This discussion pertains to one group of experiments aimed at determining the effect of zero gravity on two basic cellular phenomena: fertilization and cell division. The sea urchin eggs and sperm were used, and a device was designed by means of which sperm and eggs were mixed at the end of the acceleration phase of the flight and fertilization was then accomplished during weightlessness. Some of these eggs were fixed during re-entry and some were allowed to develop for study after recovery. Cell division was studied in much the same way. The techniques and results are discussed in detail.

341. Yuganov, E. M.
MUSCLE TONE DURING CONDITIONS OF WEIGHTLESSNESS (O MYSCHECHNOM TONUSE V USLOVIIAKH NEVESOMOSTI), by E. M. Yuganov, I. I. Kas'iam and V. I. Yazdovskii, Izvest, Akad. Nauk S.S.S.R. Ser. Biol., v. 25, 1960, pp. 601-606, (in Russian).

ADDENDUM

A

342. Aero Medical Association, St. Paul, Minn.
1953 LITERATURE AVIATION MEDICINE AN ANNOTATED BIBLIOGRAPHY, VOLUME 2, by A. J. Jacobius, M. Wilkins, L. Kassianoff, R. B. Slie, et al., 1959, 34 pp., 1386 refs.

This bibliography on aviation medicine covers 1953 literature and some studies from 1952 not included in the first volume. The items, which consist of the complete reference and an informative abstract, are arranged alphabetically with cumulative author and subject indexes included. Areas of subject coverage are: 1) history and general aspects of aviation medicine, 2) aviation psychology, 3) pathology and pharmacology, 4) aviation physiology, 5) preventive medicine and sanitation, 6) special problems in high-altitude and space flight, and 7) miscellaneous problems.

343. Air Force, Aeronautical Systems Div., Behavioral Sciences Lab., Wright-Patterson AFB, Ohio.
HUMAN ENGINEERING PRINCIPLES OF DESIGN FOR IN-SPACE MAINTENANCE, by L. D. Pigg, Proj. 7184, Task 718406, Rept. no. ASD TR-629, Nov 61, 10 pp.

Results of research on problems related to human performance of maintenance actions in space systems are reviewed. The interactions of sensory, psychomotor, and motor functions are discussed, along with problems of remote-handling applications in the space environment.

344. Air Force, Aerospace Medical Div., Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.
A PULSE FUNCTION, SINGLE AXIS, COMPENSATORY TRACKING APPARATUS, by N. F. Schwartz, Rept. no. ASD TR-61-734, Dec 61, NASA N62-12764, 11 pp., (OTS $ 0.50).

An apparatus which provides a one-dimensional compensatory tracking task for psychological research is described. A photograph schematics and description of the circuitry are included. The apparatus was developed to fulfill the requirements of a task designed primarily to compare tracking performance under normal gravity to performance under zero or other abnormal gravity. The task is to attempt to keep the spot on a cathode-ray tube centered using an aircraft or similar type control stick. Programmed pulses having either of two amplitudes and durations and separated by either of two intervals cause the spot to suddenly move vertically either of two distances up or down from center when being tracked. These

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pulse parameters are programmed to seem random. The forcing function pulses driving the spot and the subject's response can both be recorded to yield specific data and, as presently used, afford a comparison of normal tracking performance with performance under zero gravity.

345. Air Force, Headquarters, Air Research and Development Command, Andrews AFB, Washington, D. C.
FOOD FOR SPACE TRAVEL - AN EXAMINATION OF CURRENT CAPABILITIES AND FUTURE NEEDS, by A. A. Taylor, B. Finkelstein and R. E. Hayes, Rept. no. ARDC-TR-60-8, Jul 60, AD 241 869, 64 pp., 20 figs., 67 refs., 3 appens.

The state of progress and present capabilities in nutrition, food technology, and food service supporting equipment for manned space flight are described and evaluated in terms of future needs.

The study is broad in scope. It describes feeding in very short to very long space missions. Preflight feeding provisions are described as well as partially regenerative systems and, finally, the requirements of a closed ecology are considered. A section is devoted to permissable preflights foods. Varied menus are offered for flights of short, medium, and long duration in an ascending order of variety, consumer acceptance, and support equipment.

346. Air Force Systems Command, Aerospace Medical Div., 6570th Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.
SPEECH DURING WEIGHTLESSNESS, by C. W. Nixon and C. E. Waggoner, Proj. 7231, Task 723103, Rept. no. MRL-TDR-62-45, May 62, NASA N62-16589, 10 pp., 3 figs., 4 tbls., 6 refs.

Certain characteristics of human speech exhibited under 1-g conditions may be different under weightless conditions. If such differences exist, they might interfere with satisfactory speech communication under conditions of zero gravity. Standard speech materials recorded under conditions of 0 g, 1 g, and 2-1/2 g's were evaluated by both objective and subjective methods. Results indicate that speech production is not significantly altered by brief periods of zero gravity. Reception of speech also seems to be unaffected. Both speakers and listeners indicate good speech intelligibility under conditions of weightlessness.

347. Air Force Systems Command, Aerospace Medical Div., 6570th Aerospace Medical Research Labs., Behavioral Sciences Lab., Wright-Patterson AFB, Ohio.
PERCEPTION OF THE VISUAL VERTICAL UNDER REDUCED GRAVITY, by L. R. Hammer, Proj. 7184, Task 71805, Rept. no. MRL-TDR-62-55, May 62, 13 pp., 3 figs., 4 tbls., 31 refs. (OTS $0.50).

Continued

Judgments of the vertical in an unstructured visual field were obtained in flight under four levels of gravity ranging from 0 G to 1 G. Reduced- and Zero-Gravity conditions were produced in a cargo aircraft flying a parabolic trajectory. Each of 16 subjects made 6 judgments under each of the 4 G-condition Results indicate that, although error of judgment of the vertical is not large, it does increase as the G-level decreases, from 1.8 degrees at 1 G to 3.5 degrees at 0 G. Conditions associated with inflight research and discussed and suggestions for future research are presented.

348. Air Force Systems Command, Aerospace Medical Div., 6570th Aerospace Medical Research Labs., Behavioral Sciences Lab., Wright-Patterson AFB, Ohio.
PSYCHOMOTOR PERFORMANCE UNDER CONDITIONS OF WEIGHTLESSNESS, by J. E. Wade, Proj. 7184, Task 718405, Rept. no. MRL-TDR-62-73, Jun 62, 7 pp., 3 figs., 2 tbls., (OTS $0.50).

Subjects operated three different sets of switches as they were flown through 0-G trajectories in a C-131B aircraft. Push-button, toggle, and rotary switches were each paired with a master push-button switch to form the three sets used to turn an indicator light on and off. The subjects were instructed to perform the task as fast as possible by alternate actuation of the two switches of each set. Each subject also performed in straight and level flight with each set of switches for control data. Performance data, along with aircraft accelerative forces in three dimensions, was recorded on a high-speed oscillograph.

Small net statistically significant decrements were found in speed of operation of all three sets of switches in the 0-G environment in comparison with performance at 1-G. The toggle switch set showed the greatest decrement, the rotary switch set the least decrement. The push-button switch set was operated most rapidly in both 1-G and 0-G conditions.

349. Air Force Systems Command, Aerospace Medical Div., 6570th Aerospace Medical Research Labs., Biomedical Lab., Wright-Patterson AFB, Ohio.
SLEEP AND ALTERED PROPRIOCEPTIVE INPUT AS RELATED TO WEIGHTLESSNESS: WATER IMMERSION STUDIES, by D. E. Graveline and M. McCally, Proj. 7222, Task 722201, Rept. no. AMRL-TDR-62-83, Aug 62, NASA N62-16543, 12 pp., 5 figs., 8 refs.

The "free-floating" condition of immersion is associated with substantial alterations in mechanoreceptive feedback to the central nervous system in a manner similar to the free-floating condition of weightlessness. One area having rather immediate operational application concerns sleep under these conditions. In this study electroencephalographic and electro oculographic recordings were made during sleep of completely

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immersed, neutrally buoyant subjects. Sleep records were obtained while using both tether and clamshell sleeping facilities and were compared to each subject's normal bedrest sleep records. The results are presented and their possible application to prolonged weightlessness is discussed.

350. Air Force Systems Command, Foreign Tech. Div., Wright-Patterson AFB, Ohio.
BEFORE A MANNED FLIGHT, by L. Gil'bert. Trans. no. MCL-1280/1, 17 Aug 61, AD 269 661, 13 pp., illus., Trans. from: Znaniye-Sila (Moscow), v. 10, pp. 6-8.

The effect of g-forces (acceleration and deceleration) and of weightlessness are discussed; test equipment are also mentioned.

351. Air Force, Wright Air Development Center, Wright-Patterson AFB, Ohio.
ZERO GRAVITY RESEARCH AT WRIGHT AIR DEVELOPMENT CENTER (a film), by E. Brown, 16mm - silent - approx. 22 min. - Black and White - Unclassified.

Sequence of shots taken aloft during "Keplerian trajectories", aboard a C131B Aircraft; illustrates various problems associated with zero 'g' states.

352. American Inst. for Research, Pittsburgh, Pa.
SPACE PSYCHOLOGY: SOME CONSIDERATION IN THE STUDY OF ASTRONAUTS' BEHAVIOR, by R. W. Smith and J. W. Altman, Apr 61, 90 pp., 4 tbls., 186 refs.

The following environmental factors and their potential implications for human behavior are discussed: altered atmospheric characteristics, high gravitational loads, weightlessness, temperature, radiation, noise and vibration, isolation and confinement, sexual deprivation, time, and encounters with alien factors.

353. Army, Library, Adjutant General's Office, Washington, D. C.
MILITARY ASPECTS OF SPACE EXPLORATION, Spec. Bibliography no. 16, Jun 58, 55 pp., 300 refs.

This bibliographic survey was made to throw light on available unclassified literature that points up the military implications of space exploration. The materials are arranged in alphabetical order by title within major and subordinate subject groups. The major groups are miscellaneous; United States space effort; Soviet Russia space effort; satellites, trends and developments (electronics, navigation, orbits, propulsion, guidance control, and telemetry); environmental factors and problems (acceleration, survival, weightlessness); exploration of the moon and Mars; space ships and stations; international and legal aspects; and conferences, conventions, and symposia.

B

354. Brannan, P.
DRML SCIENTISTS PROBE MAN'S SPACE LIMITATIONS,
Can. Aviation, v. 33, no. 3, Mar 60, pp. 8-11.

The work of the Defence Research Medical Laboratories at Downsview, Ontario, Canada, towards the solution of the problems of weightlessness and motion sickness in space travel is discussed. Muscular deterioration, circulatory changes, and problems of movement, as results of the weightless condition, are briefly considered. Experiments on motion sickness resulting from the utilization of angular acceleration to counteract weightlessness are also described.

355. Brown, E. L.
"Human and System Performance During Zero G" pp. 85-90, in;
VISTAS IN ASTRONAUTICS, Volume III, Society of Automotive Engineers, Inc., New York, 1960, 266 pp.

Research areas covered by this article include: (1) Human performance on motor and mental tasks; (2) Locomotion of Individual humans inside large space vehicles; (3) Locomotion of Individual humans outside space vehicles; (4) Human perceptive orientation during zero g; (5) Behavior of liquids during zero-g; (6) Fluid transfer problems during zero g; and (7) Heat transfer problems during zero g.

356. Buchheim, R. W.
SPACE HANDBOOK: ASTRONAUTICS AND ITS APPLICATIONS, by R. W. Buchheim and RAND Corp. Staff, Random House, New York, 1959, 331 pp., 76 figs., 16 tbls., refs.

Chapter 15 entitled "Environment of Manned Systems" includes a short section on weightlessness.

C

357. California, Univ., Space Sciences Lab., Berkeley
BIOLOGICAL SYSTEMS INTERPLANETARY ENVIRONMENT, Ed by J. V. Slater, NASA Grant NsG-94-60, Semiannual status rept., series 3, issue 3, 28 Feb 62, NASA N62-12476, 26 pp., 3 refs. (OTS $2.60).

In studies of weightlessness, theoretical analysis of particle flow during convection and diffusion indicates that flow rate in a difusion cell is proportional to the component of gravity in the direction of the linear part of the cell.

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The influence of relative humidity and other environmental factors on embryonic development in Tribolium has been under investigation. Desiccation or high relative humidity (78 percent) had little influence on wing development at 30°C (optimum temperature for minimal wing damage), although the total number of pupal deaths and molting failures rose considerably. Temperatures lower than 25°C drastically affected development in the absence of atmospheric water. Pupae held in a head-down position are little affected as far as wing development, but the total number of molting failures increases sharply. This was not evident at 30° but at 38° was quite obvious. Over three times as many abnormalities occurred when the organisms were held in any position as compared with the controls. Pupal deaths rose sharply after 16 hours exposure to pure CO_2, although wing differentiation remained relatively unaffected. Phenotypes of known mutants were induced in Tribolium by the use of various agents, including boric acid, insulin, temperature changes, radiation, shaking, ether, and dietary changes. Post-irradiation incubation at 30°C results in minimal abnormalities.

358. Campbell, P. A.
"Aeromedical and Biological Considerations of Space Flight," chapter 5, in; REALITIES OF SPACE TRAVEL, Ed. by L. J. Carter, Putnam, London, 1957.

359. Campbell, P. A.
AVIATION MEDICINE ON THE THRESHOLD OF SPACE: GENERAL CONSIDERATIONS, Ann. Intern. Med., v. 50, no. 6, Jun 59, pp. 1542-1549.

360. Campbell, P. A.
ESCAPE AND SURVIVAL DURING SPACE OPERATIONS, AUQR, v. 10, no. 4, Winter 1958-59.

361. Campbell, P. A.
"Human Factors Aspects of Weightlessness" pp. 443-464, 7 figs., tbl., 32 refs., in; ADVANCES IN SPACE SCIENCE AND TECHNOLOGY, Volume 3, Ed. by F. I. Ordway, III, Academic Press, New York, 1961.

The material in this chapter is devoted primarily to considerations of weightlessness insofar as it affects human factors and life-support systems. However, it is not intended to detract from the importance of the phenomenon from the viewpoint of many other disciplines and technologies. Problems of direct interest to engineers undoubtedly are equally important as those of the physician, the psychologist, and the biologist, but are not discussed herein.

362. Campbell, P. A.
HUMAN PARAMETERS OF SPACE FLIGHT, USAF Med. Service Digest, v. 9, no. 3, May-Jun 58, pp. 2-10.

363. Campbell, P. A.
MAN IN SPACE: WHERE WE STAND, Air Force & Space Digest, Jul 59, pp. 65-67.

364. Campbell, P. A.
"Orientation in Gravity-Free Space" in; Illinois Symposium on SPACE MEDICINE, Univ. of Illinois Press, 1951.

365. Campbell, P. A.
THE PRESENT SPACE MEDICINE EFFORT AT THE SCHOOL OF AVIAION MEDICINE, USAF, U. S. Armed Forces Med. J., v. 10, no. 4, Apr 59, pp. 392-397, 3 figs., ref.

Describes the four departments of the Space Medicine Division of the School of Medicine. They are Astroecology; biogravics, which is concerned with studies of the effects of weightlessness on man; bioastrophysics; and bioastronautics.

366. Campbell, P. A.
PROGRESS TOWARD SPACE FLIGHT, Federation Proc., v. 18, no. 4, Dec 59, pp. 1255-1259.

367. Campbell, P. A.
SOME MEDICAL PROBLEMS OF SPACE FLIGHT, Rev. Intern. Serv. Sante Armees Terre Mer Air (Brussels), v. 32, nos. 2-3, Feb-Mar 59.

368. Carpenter, M. S.
"Pilots Flight Report" pp. 69-75, in; RESULTS OF THE SECOND UNITED STATES MANNED ORBITAL SPACE FLIGHT, MAY 24, 1962, Rept. no. NASA SP-6, Government Printing Office, Washington, D. C., 1962, 107 pp., ($0.65).

An account of the major events and personal observations of the MA-7 flight is reviewed by the pilot. Prior to and during powered flight, launch-vehicle noise and vibration were less than expected. As the MA-6 mission, the astronaut quickly adapted to weightless flight and remarked that it was more comfortable and provided greater mobility than under normal gravity. Astronaut Carpenter also observed the space particles and the bright horizon band, previously reported by John H. Glenn, Jr., and secured new information on both phenomena. The final phases of the flight, including retrosequence, reentry, landing, and egress, are covered in detail.

369. Cornell Aeronautical Lab., Inc., Buffalo, N. Y.
THE ABILITY OF SUBMERGED SUBJECTS TO SENSE THE GRAVITATIONAL VERTICAL, by W. S. Diefenbach, Rept. no. CAL-ON-1355-V-1, Jan 61.

370. Cramer, R. I.
THE RESPONSE OF MAMMALIAN GRAVITY RECEPTORS TO SUSTAINED TILT, Paper presented at the 1960 Meeting of the Aerospace Medical Assoc., 9-11 May 60, Miami Beach, Fla., Abstracted in; Aerospace Med., v. 31, no. 4, Apr 60, p. 301.

Data will be presented to illustrate the ability of single cells in the nuclear projections of the gravity receptors in the inner ear to signal sustained tilt. Decerebrate and decerebellate cats will be used. Results will be related to problems of prolonged gravity-free conditions.

D

371. Dept. of Commerce, Office of Technical Services, Joint Publications Research Service, Washington, D. C.
SOVIET STUDIES IN THE EFFECTS OF WEIGHTLESS AND PHYSICAL EXERTION, by M. P. Ivanova and A. S. Barer, Rept. no. JPRS-14796, 10 Aug 62, 33 pp., 23 refs., Trans. of; Zhur. Vysshei Nervnoi Deyatel' nosti im. (Moscow), v. 12, no. 2, Mar-Apr 62, pp. 202-207, 332-337, (OTS $1.00).

Contents:
Ivanova, M. R., "Changes in the Biopotentials of the Human Brain in Connection with Physical Work," pp. 1-15, 11 refs.
Barer, A. S., "The After-Effect of Singly and Repeatedly Acting Antripetal Accelerations on the Higher Nervous Activity of Animals," pp. 15-30, 12 refs.

F

372. Fisher, A. C., Jr.
AVIATION MEDICINE ON THE THRESHOLD OF SPACE, Natl. Geographic Mag., v. 108, no. 2, Aug 55, pp. 241-278, 42 illus.

A coverage of all aspects of space flight including acceleration, deceleration, and weightlessness.

G

373. Graveline, D. E.
DIURESIS ASSOCIATED WITH PROLONGED WATER IMMERSION, by D. E. Graveline and M. M. Jackson, J. Appl. Physiol., v. 17, no. 3, May 62, pp. 519-524, 3 figs., 3 tbls., 21 refs.

Continued

Utilizing complete water immersion, compensated respiration, and unrestricted activity, the diuretic response of five human subject to 6-hr. periods in this environment was studied. The results indicate that the low specific gravity diuresis which occurs in this situation has characteristics of both a water and an osmotic diuresis. Possible physiologic mechanisms are discussed.

H

374. Haber, H.
THE HUMAN BODY IN SPACE, Sci. Am., v. 184, no. 1, Jan 51, pp. 16-19, 5 figs.

Article discusses the measures which must be taken to enable men to survive in the alien environment of the void beyond our atmosphere.

375. Hertzberg, H. T. E.
THE BIOMECHANICS OF WEIGHTLESSNESS, Aircraft & Missile, v. 3, 1960, pp. 52-53.

376. Hillaby, J.
FLYERS DESCRIBE FLOATING IN AIR, Sci. Digest, v. 41, Feb 57.

K

377. Kuehnel, H. A.
"Pilot Performance", by H. A. Kuehnel, W. O. Armstrong, J. J. Van Bockel and H. I. Johnson, pp. 63-68, 2 refs., in; RESULTS OF THE SECOND UNITED STATES MANNED ORBITAL SPACE FLIGHT, MAY 24, 1962, Rept. no. NASA SP-6, Government Printing Office, Washington, D. C. 1962, 107 pp. ($0.65).

The results of the MA-7 orbital flight further indicate that man can function effectively in a space environment for periods up to $4\frac{1}{2}$ hours. In general, the pilot can orient the spacecraft to a given attitude by using external reference, provided sufficient time is available for determining yaw alinement. As with the MA-6 flight, the results of this flight provide evidence that the man can serve as a backup to the automatic spacecraft systems. The pilot has demonstrated his ability to operate scientific apparatus successfully in a space environment and to obtain useful data for the analysis of scientific problems associated with a terrestrial space environment. The results of the MA-7 flight provide additional evidence that man is ready for a more extended mission in a weightless environment. Flight difficulties occuring during this

Continued

mission, however, have served to emphasize that the primary attention of the pilot should be devoted to management of spacecraft systems and detailed attention to operational functions.

P

378. Potts, P.
EXERCISE IN A WEIGHTLESS ENVIRONMENT, by P. Potts and J. I. Bowring, Physical Therapy Rev., v. 40, no. 8, Aug 60, pp. 584-587, 3 figs.

Paper cites a few examples of what happens when an individual attempts to exercise in a weightless situation.

R

379. RAND Corp., Santa Monica, Calif.
"Problems of Weightlessness," by P. K. Isakov, pp. 229-239, in; A CASEBOOK ON SOVIET ASTRONOMY, Ed. by F. J. Krieger, Research memo no. RM 1760, 21 Jun 56, Also in; BEHIND THE SPUTNIKS, Ed. by F. J. Krieger, Public Affairs Press, Washington, D. C., 1958.

S

380. THE SECOND SOVIET COSMIC SHIP (VTOROY SOVETSKIY KOSMICHESKIY KORABL'), Izvestiya, no. 212, 6 Sep 60, p. 3.

381. Strughold, H.
"The Mechanoreceptors of Skin and Muscles Under Flying Conditions" pp. 994-999, in; GERMAN AVIATION MEDICINE, WORLD WAR II, Vol. II, Dept. of the Air Force, U. S. Government Printing Office, Washington, D. C., 1950.

V

382. von Diringshofen, H.
HEALTH PROBLEMS OF SPACE FLIGHT: ABSENCE OF GRAVITY (DAS GESUNDHEITLICHE PROBLEM DES WELTRAUM FLUGES: DAS FEHLEN DER SCHWERKRAFT), Grenzgeb. Med., v. 1, no. 4, Sep 48, pp. 144-145, (in German).

383. von Diringshofen, H.
STEEPNESS OF G-FALL AS AN IMPORTANT FACTOR FOR THE SENSATION O WEIGHTLESSNESS (RAPIDITA DELLA DIMINUZIONE DELLA GRAVITA COME IMPORTANTE FATTORE DELLA SENSAZIONE DI ASSONYA DI PESA), Rev. Med. Aeronaut., Numero Unico, Congresso Internazionale di Medicine Aeronautical di Lovanio, 23-27 Sep 58, p. 11, Paper presented at the International Congress of Aviation Medicine, Sep 58, Louvain, Belgium.

384. von Diringshofen, H.
WHAT IS THE PROBABLE BEHAVIOR OF THE HUMAN ORGANISM IN GRAVITY FREE SPACE? (WIE WIRD SICH DER MENSCHLICHE ORGANISMUS VORAUSSICHTLICH IN SCHWEREFREIEN RAUM VERHALTEN?), by H. von Diringshofen, H. Schaefer and H. Strughold, Weltraumfah v. 2, 1951, pp. 81-88.

Y

385. Yazdovskii, V. I.
POSTURAL REFLEXES OF INTACT ANIMALS UNDER CONDITIONS OF WEIGHTLESSNESS (USTANAVOCHNYI REFLEKS INTAKTNYKH ZHIVOTNYKH V USLOVIIAKH VEVESOMOSTI), by V. I. Yazdovskii, E. M. Yuganov and I. I. Kas'ian, Izvestiia Akad. Nauk S.S.S.R. Ser. Biol., v. 25, 1960, pp. 762-767, (in Russian).

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AD 306 007	[illegible]
AD 31[illegible]	[illegible]
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